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PREFATORY NOTE

SIGNATURES and catchwords, imprints and colophons, typefaces and watermarks, are as fundamental and important to bibliographers as cellulose and bones to botanists and anatomists. All arouse unquestioned enthusiasm among their disciples, and this enthusiasm calls for neither defense nor apology.

There is no reason, however, why botanists and anatomists should not occasionally rejoice at seeing flowers in the garden or enjoy watching animals at play, not only rejoice but perhaps enlarge their knowledge and their acquaintance with their own special subjects.

It was with some such feeling as this that the Bibliographical Society devoted its Chicago meeting in December, 1930, to a study of the fifteenth-century book, as a book, as the printed word sent out by a man with a message. The results of this series of studies are here set forth, and to the kindly efforts and sympathetic response of Messrs. Ivins, Kinkeldey, Klebs, Plucknett, Read, and Smith are due the thanks of the Society and of the individual members, both as bibliographers and as bookmen.

H. M. L.

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ARTISTIC ASPECTS OF FIFTEENTH-CENTURY PRINTING

By William M. Ivins, Jr.

RARELY have I been so flattered as when you, a body of professed bookmen, invited me, a rank outsider, to address you upon the artistic aspects of fifteenth-century bookmaking. Had it not been for my acute sensibility to that flattery, and had it not been that your invitation offered me an excuse and an occasion for trying to find out what I actually thought about the incunabula, I should doubtless never have accepted your invitation. But I did accept it and thereby all of us have been "let in for it."

In beginning this address one further word of explanation and apology is necessary. Your invitation asks me to talk to you about the artistic aspects of early printing, a fact which, knowingly or not, implies if not a discussion at least some definition of the word "artistic." I shall therefore presume that by artistic was meant what is often called "beauty" or "beautiful," and I must immediately follow that presumption by the statements that I do not know what any of those three words mean and that I personally use them as rarely and as discreetly as possible. Some people like some things and others like other things, and while this leads to much futile discussion it rarely or never results in any agreement or definition that is capable of being concretely applied. It does happen, however, that people in the mass at any time and place produce things that have certain common traits, and that other people in other places and at other times have a tendency to like or to dislike those things. When they like them they call them "artistic" and "beautiful,"

and when they dislike them they call them "inartistic" and "ugly." Therefore if we would really address our thought to the artistic aspects of any things made in the past we must think as much about ourselves and our immediate past and present conditions as about the objects that titularly we are discussing, for if we leave ourselves and our own histories out we are, so to speak, not only leaving out Hamlet but forgetting our enacting clauses.

My years in the museum of art have brought me to believe that only two kinds of useful objects are generally capable of being thought beautiful—things that are in the last word of fashion, so new that their varnish is sticky, and things so old that they have ceased to have any functional validity and have become in general quite useless. A well-known German philosopher was so impressed with this latter aspect that he built up a great edifice of aesthetic theory upon it, maintaining that beauty was the utility of the useless. The usual life-history of any object intended for use, if it survive long enough, is that it is useful, that it is no longer useful, that it is a curiosity, and that it is a museum piece. Anything, so long as it is in active use, rarely gets a chance of being regarded from any point of view other than that of its utility. And as matter of hard fact, there are very few people who are able to recognize any particular aesthetic appeal in a useful thing.

The history of the early printed books is as pat an illustration of this general thesis as can be desired. To begin with, the really useful early books—that is, those that were really useful to their original purchasers—are today among the greatest rarities. When most of us think of incunabula we think of big books in biggish type upon subjects more calculated to produce sleep than action. A nice, handy, readable incunabulum is a day's wonder, but not because they were not produced, for they were, but because they have been worn out and have vanished. In a collection of about one hundred and sixty Florentine illus-

trated books with which I am somewhat familiar about fifty are either the only copies known or have never been described by the cataloguers, and many of the others are known in only three or four or five copies. With three or four exceptions they are all small books. Thus if I may generalize, and frankly I expect to do a great deal of it before I am through today, I think we may take it for granted that we really have little or no conception of what the contents of a book-dealer's shelves were like in some such year as 1495. The books of that time that we know are almost without exception books that were either so learned or so big and clumsy that they were put on the top and bottom shelves and not on the shelves that were easy to reach. In the course of time these outsizes and heavyweights graduated to the attics and the conventual libraries, where they survived because they had been forgotten.

The earliest books about early printing, if my memory is correct, were catalogues that appeared in the second half of the seventeenth century. I have never examined any of these books, except several about the history of printing in France, but I have no recollection of having heard or read any statement to the effect that these early cataloguers ever made any comment upon the beauty of the books they were busy recording. Private collecting of old books has always been a favorite pastime, but I see no reason to believe that the old collectors were so very different from most of their more modern successors, and I believe that their thoughts were directed far more at the rarity and the curiosity and the interest of their collections than at their beauty. In any event the eighteenth century produced a great crop of noble and wealthy collectors. It was the century that saw the development of a fashionable feeling for the Gothic and in which the romantic played a very definite rôle in both literature and architecture. Batty Langley's carpenter's handbook on *Gothic Architecture* came out in 1747, and if one goes through the pattern-books produced in England in

the second half of the century, one will find a steadily increasing vein of gothicizing design. All through the century England was building, along with its classical buildings, a steady stream of little country churches and private residences in the "Gothic style," and in France the cathedral of Ste-Croix d'Orléans. built in full *dixhuitième*, is a Gothic construction. Horace Walpole, so far from being an oddity, was in fact most carefully at the forefront of dilettante fashion. At the turn of the century, just as the romantic writers in Germany and England were coming into fashion, there came the French Revolution and the subsequent political and social upheavals on the continent of Europe. One of the first results of these upheavals was the breaking-up and dispersion of countless numbers of old libraries, in both great country houses and convents, on whose shelves the old books had lain in dust and security for centuries. Not only was there a supply of old books available for the first time in history, but the contemporary romantic gothicizing fashion led men to take an enormous interest in them. The result was the formation of such a series of private libraries as had theretofore never been known—libraries that prided themselves upon their count of ancient books. It is needless for me to call your attention to a list of names such as those of Heber and Cracherode, Grenville and King George III, but it is perhaps worth while to note in passing that the greatest accumulation of incunabula in the world, that in the Munich Library, was the immediate result of the French invasion and the subsequent impounding by the state of practically all the Bavarian conventual libraries. At no other time would it have been possible for Rev. Thomas Frognall Dibdin to write as he did, enthusiastically and bombastically, about the treasures of Roxburghe and of Spencer, or for great noblemen and nabobs to have underwritten his travels and to have paid for the printing of his books. Prior to Dibdin, Ames had produced a few halting facsimiles of old types, but only as curiosities; Dibdin not only

reproduced pages and samples of old type, but hundreds of old woodcuts, and for the first time in history let a goose quill take flights of rhetoric and aesthetic appreciation about the work of the old bookmakers. It would be utterly to misunderstand Dibdin to think of him as anything other than a particular symptom of the romantic revival as conditioned by the break-up of the old libraries. He and the attitude he typified were the result of a fashionable sentiment working upon the ruins of a civilization.

The Gothic revival went on to ever increasing heights of silliness. In England it tied on to the ferment in the church. In France the youthful Victor Hugo in an excess of patriotism acclaimed Gothic the only native and therefore truly national style. In Germany it was made fast to the sentimentalities of all kinds. Everywhere people had Gothic dining-rooms, though no such things had been known in Gothic times, and Gothic mantels and Gothic chairs. In England Pickering produced, for the first time in several hundred years, except for chapbooks for the hedgerows and reprints of lawbooks for the inns of court, a series of prayer and devotional books in quasi-Gothic type. In France Curmer produced an elaborate chromo-lithographed *Book of hours* in imitation of a fifteenth-century book, and other publishers a long run of reprints in black letter of the old French verse that had been forgotten since the early part of the sixteenth century. The thing lasted longer and bit in harder in England than anywhere else, for not only had England never been overrun by armies in the middle of the seventeenth century, so that it still had more of its ancient monuments than any other country, but it was rich, rich in cash as the result of the economic revolution, and it was undergoing a religious revolution to which the Gothic peculiarly lent itself. Mason Neale translated the first book of Durandus and Willis published copies of the drawings by Villard d'Honnecourt. Pugin and Gilbert Scott peppered Gothic churches all over the land. The new

houses of Parliament were in Gothic, and so a generation later was the Albert Memorial. Long after the Gothic rash had subsided in other countries it kept on in full swing in Great Britain. Ruskin was fulminating about the stones of Venice and the Gothic cathedrals, and the pre-Raphaelites were spreading their doctrine and filling the land with pictures and ideas. In the sixties and seventies Sir Charles Eastlake not only wrote a history of the Gothic revival but published his epoch-making book of *Hints on household taste*. In the sixties a minor member of the P.R.B. started an interior-decoration firm, and made Burne Jones tapestries and Morris chairs, and preached solemnly and loudly through a vast Gothic beard about socialism and guilds and old poetry, and wrote interminable romances in a strange gothicizing lingo and yards of, save the mark, interior decorated poetry! He was a small 32mo in size but he had the weight and the energy and the vitality of an elephant folio. What he didn't know about advertising was unknown to any man of his time, and before long all the *nouveaux riches* were living in the atmosphere of "Ha! Ha! La belle jaune giroflée," and sweet young things were being, oh, most rectilinear and intense! For many years William Morris contented himself with amateur calligraphy and illumination, making sure that his books were printed in legible, handy form and sold at prices that did not interfere with their circulation. Toward the end of his life he began to collect illuminated manuscripts and early books—ease had come to him with age and also a certain weariness—and out of these there came the Kelmscott Press, a matter of but six or seven years between its first publication and its last, in which Morris, starting as play, built up a real business in printing what Charles Lamb would have called *biblia abiblia*—books that are not books. Morris designed books as he designed textiles, as all-over designs. Every time that he could introduce a tail or a wiggle on a letter that would interfere with legibility he did. He filled his margins with tapestry ef-

fects. He sought for illustrations that would look as much as possible like type pages and that would melt into them as inconspicuously as possible. He issued his books on thick, heavy, intractable paper. He bound them in curling, twisting vellum and tied them together with stout linen tapes, so as to make them more difficult to hold and to open. They were perfect for people who never read or used any books but *Poor's manual* and *Racing form*, but who liked for respectability's sake to have a book or two about the house. And just as all the "arty" of the English-speaking world had fallen for his tapestries and painted jerry-built furniture, so it fell for his books. The great effectiveness of the teaching and example of William Morris was due in very large measure to the authority that his familiarity with artists and works of art, and his long career as poet, novelist, translator, and interior decorator gave to his pronouncements. However prejudiced and wilful his ideas about all these things were, they lent vast power to his equally prejudiced and wilful ideas about books, for he saw them all in relation to one another. In short, his power was based on a culture, extraordinarily deep and genuine in spite of its warpedness, that has been equaled by that of few or none of his emulators. Had his followers also been really cultured men, the results would have been different, but as it was, it wasn't long before the groan of the private press had spread to this side of the Atlantic and industrious, misguided men were turning out *Rubáiyáts* and *Agricolas* at every four corners. Books had to be strong and masculine, and this was translated as meaning paper like cardboard, ten times too much ink, and type faces that were torture to read.

Before long the advertising clan woke up to what Morris had in mind, or rather to what he pointed the way. Books not being meant to be read but to be looked at, both pages at once—and, if you don't believe me, look up the essay on printing design in the volume of *Arts and crafts essays* that Morris sponsored—it was but natural that for a large section of a commu-

nity in which printing was dominated by the advertising firms, it was obvious that printing was good not in proportion to its clarity and legibility all the way through a book, but in proportion to its sheer physical-shock value on a casual inspection. It wasn't long before in America Venetian fifteenth-century printer's marks were decorating cartons of saltines, and degradations from Ongania's *Arte della stampa* were on every advertising dodger and pamphlet.

And now, to go back again and to pick up another thread in the story of the evolution of the taste for fifteenth-century printing. When the librarians in the great public libraries in Europe, and especially in England, began really to buckle down to their tasks, they found themselves faced by the problem presented by all the books that were neither signed nor dated by their printers, and by that large proportion of early books that had lost their first and last leaves. At last a librarian at Cambridge suggested that the type used in the undated books of any given printer might be used as a means of identifying their approximate dates—a kind of botanizing of old books. This brilliant idea was not in the least hurt by a widely spread belief that every early printer designed, cut, and cast his own type. The belief and the idea, working together, put this counting of typographic stamens and pistils on a new basis. Robert Proctor sat down and catalogued all the incunabula in the British Museum and many of those in the Bodleian under the names of their printers and their dates of publication in accordance with this typological scheme. In less than no time librarians and bibliographers were all mad on the subject of the types in early books. They bought books for their types—and the dealers began to mention the types in their catalogues. Proctor's foolishly exuberant statement that he had never seen a book printed before 1501 that was not beautiful and rarely seen one printed after that date that was beautiful was given wide currency, for who should know more about it than Proctor, who

had done that particularly wonderful piece of cataloguing? Then there came out a long series of catalogues of libraries done on this scientific basis. It was really very advanced in philosophic and scientific attitude—those in the know knew that it was a schematic way of handling a horrid problem of classification, a great big *als ob*, but those who were not (and they were most of them) took it as being true because it was scientific. The *British Museum catalogue* was the first of these catalogues on a large scale—a very marvelous piece of work. Others, public and private, followed it. Then came a census of incunabula in the United States. And within less than no time the great European dealers were printing in their descriptions of their books the statement in English, "not in the British Museum," "not in the U.S.A.," "only one copy in Winship."

Well, it was all very simple. Here were things so old and so rare that it was worth people's time to catalogue and make censuses of them. By expert definition all early printed books were beautiful. As degraded on the hangings in the richest homes and the cracker-boxes in the corner groceries, their designs were familiar to almost everyone. Their prices were going up by leaps and bounds. Men of every kind learned how to open an old book and, sweeping a fumbling hand over it, to ask you if it was not a beautiful page. In all the history of collecting of every kind there had been nothing like it. It was made to order to the size and fit of the timid man with money in his pocket, of the man who wanted a good gamble, of the man who needed to buy and then to exhibit his culture behind a glass case.

Early printed books were beautiful, and the most beautiful thing about them was that it was necessary neither to read them nor to understand them!

Now, there always has been, and there always will be, a group of enlightened collectors who use their eyes and their aesthetic intelligence and their real culture in the formation of

their libraries. For these men, who existed before incunabula officially became beautiful, and who will exist after the timid and the gamblers and those in need of purchasable evidences of culture have turned their attention to other things, no one can have anything but the deepest respect. As a rule you can tell them on sight just as you can the others, but they take their books quietly and easily, they have real opinions that are not mere parrot-like repetition of meaningless abracadabras, and their hands don't fumble when showing the beauty of a page.

Now let us see if it is possible for us to look through all this matter of fashion and advertising and fable and gambling and tinsel culture and find out what the actual facts about the beauty of early books are.

Most people have an idea that medieval manuscripts are all beautiful. It comes about because the only ones that are put on exhibition in the great libraries and museums are those that are worth looking at. But as cold, hard matter of fact, if anyone were to wade through the accumulations of manuscripts in such collections as those in London and Paris or the erstwhile Phillips collection, it would become obvious to him in a very short time that the typical medieval manuscript was a very sloppy, clumsy, inelegant, unbeautiful thing, hastily and carelessly written and, if illustrated, illustrated with childish drawings.

When people began to print they followed in the trail of the calligraphers. Their letter forms, their page forms, their paper, were all taken over from the makers of handwritten books. So also were their pictures. And just as the greater number of medieval manuscripts are literally bad, so is the greater number of early printed books. The thing that makes such a collection as that in the Pierpont Morgan Library so wonderful is not its number or its rarity but the unusually careful selection that has gone into its making.

Leaving aside the books that are bad, the remainder fall al-

most without exception into one or the other of three classes: handsome pieces of printing, books that have historical or textual importance, and illustrated books. For anyone except the scholar, books of historical and textual interest have no valid claims, to begin with because only the scholar can read them, and, second—but the first reason was enough, especially as it brings us to several matters that really need discussion. The first and most important of these is summed up in the question, What is a book for, anyway?

It is a simple question and it would seem to be a fundamental one, but, curiously, it is one that is very rarely considered by book-collectors. Personally I believe that a book is primarily a means of preserving words and pictures, a kind of oral and visual memory that men have invented to their own great good and advantage. Words and pictures are the two substantive things in a book; all the rest is adjectival and comparatively of little importance. This is a point, it seems to me, of such great importance that I hardly know how to emphasize it sufficiently. Unless the fact that books are primarily a means for the preservation and easy consultation of texts and pictures is borne constantly in mind, any discussion of the aesthetic and other qualities of bookmaking is sure to go awry. The printed picture preceded the printed text by at least a generation. Then came the printed text sometime between 1445 and 1455. By 1460 these two things were combined by Albrecht Pfister, of Bamberg. Thereafter came the adjectival problems to which artistic printers, collectors, and historians have devoted so much of their time that they have frequently completely forgotten the matter of primary function. Again and again in reading and listening to discussions of early and other printing I have been reminded of the way that lovely ladies discuss motor cars—much talk about their color and their upholstery but never a word about their engines and chassis or their ability to stand up and deliver transportation.

The technical development of bookmaking bears out my belief that the primary purpose of a book is to be a kind of pictorial and textual memory. Very few of the surviving early books, with their heavy paper, their generally large size, their thick and clumsy type, can have been very efficient memories. They demanded too much time and strength. It was not very long before the educated public realized this or before the printers began to cope with the problem. Like the motor-car manufacturers of our own day, they began to study such things as wind resistance, centers of gravity, and speed. The first printer really to introduce low-slung bodies, stream lines, and pick-up into his books was Aldus Manutius, of Venice, and his contemporaries and followers repaid him for it by calling him the greatest of all printers. They who had actually ridden in the clumsy, high, stiff, one-cylinder, chug-chugging, De Dion Boutons of the previous epoch all threw them over with a shout of joy on the introduction of the modern motor cars. They who had used the early books as books and not as showpieces and models for advertising knew and sighed with relief over the invention of Aldus. The simple fact was that as books early books were inefficient and clumsy, however monumental and beautiful some of them may appear to us. As compared with the good, simple, light, modern book, the fifteener was about as a blunderbuss is to a service automatic, as decorative on the wall as it was faulty in the hand. And we can get the test of it in several ways. Remembering that form is the result of adaptation to function, it is to be noted that no books meant for use have been produced in fifteenth-century forms for a great many hundred years. Had those forms been adequate to their function, this would not have been true; they would have persisted across the ages, as have things like the nib of the pen. Another way is to remember that histories, commentaries, criticism, only abound or have great merit when their material is easily and quickly available, and then to notice that none of the books based on books

which anyone still consults were produced during the period of the early books. The modern book appeared soon after 1500, and made possible that flood of sixteenth-century texts that is part of the heritage of every cultivated man.

Thus, since to all but the specialist fifteenth-century books are not only of no interest but, because of the tongues in which they were written, illegible, what is left is the adjectival of handsome printing and the substantive of illustration. Only a comparatively small proportion of the work of the early printers is illustrated, and a large proportion of such illustrations as there are is of very doubtful artistic importance. There is, however, a remainder that is of solid gold, carefully to be sought and jealously to be guarded. It would be too great a task to give the names of more than a very few of these books or to attempt any detailed discussion of their merits. The histories of early printing, and especially of what are called "fine books," contain much more than is known about them, and so to try to tell you anything myself would be a mere confounding of confusion—and, after all, a catalogue of names and dates of first use, of initials and woodcut borders and types and all the other things that the historians set such store by, would be merely a useless weariness to all of us, for in truth they are but dead and dull exercises and far aside from the point of this article. The thing that we really have to do is to look at our early books and their illustrations in order to see, if we can, how they fit into our pictures of the societies that gave birth to them, their relationship to the cultures out of which they came. If we can find out something about that, why, then, perhaps we shall be making a stride of some sort toward a real understanding of their artistic aspects. Some years ago Max Dvořák, of Vienna, coined a phrase that should be always before the eyes of anyone who even pretends to take a serious interest in the art of the past: *Kunstgeschichte als Geistesgeschichte*—the history of art is merely one aspect of the history of the human spirit. If we

put art under a bell glass and exhaust from it that life-giving history of the human soul under civilization, we no longer have art or spirit but at best a collection of dry bones for fashionable attitudinizing.

When we survey the early printed books of European origin we find immediately that they fall into two large groups and three smaller ones. The two large groups are composed of the volumes made in Germany and Italy, respectively, and the three smaller ones of books made in France, Holland, and the Iberian Peninsula. In this paper I shall make no attempt to discuss any but the books of the two great groups, not only because I am more familiar with them, but because the books of the three small groups are in general of such rarity that very few Americans have any opportunity of seeing or knowing them. I may remark, however, in passing that the illustrated Dutch and French books of the fifteenth century show strong evidences of having sprung from much sturdier and more highly developed artistic traditions than the German ones, there being no German books until the very end of the century that contain pictures comparable with those in such volumes as the first *Ars moriendi*, the *Canticum canticorum*, the *Chevalier Délibéré*, the *Grandes chroniques*, or some of the Parisian *Horae*. There is no more reason to seek for any precise similarity between these several groups of books than there is to seek for a precise similarity between the paintings, or sculpture, or architecture, or literature produced in their various countries during the second half of the fifteenth century. Each of these lands had its own culture and beliefs and habits, and each was quite foreign to all the others. The only things the bookmakers of these countries had in common were a mechanical technique, and, in the very beginning, a large number of Teutonic workmen. It is therefore impossible, except at the cost of an abstraction so great as to verge upon emptiness, to think of their books, or to discuss them, in terms of anything but their coun-

tries of origin. A German book has one kind of look and an Italian one another, and the difference between them is not so much a matter of local taste, either then or now, as it is a matter of different histories and different surroundings. The German woodcuts—because for the moment we are talking only of illustrations—found their origins, as far as we can tell, in the studios of the illuminators, that is, in the workshops of the minor draftsmen and painters of minor and provincial schools. The Venetian illustrations and borders found their origin also in the studios of groups of illuminators, but schools that differed from the German ones in working at one of the great metropolitan centers of artistic activity. The Florentines are most intimately associated with the lesser painters of the school of Botticelli. The difference may be put in this way, that whereas the German woodcuts and borders have no monumental quality and no feeling of either space or relief, those made in Venice show very definitely an architectonic quality that is most closely allied with such major monuments as the great Renaissance tomb sculptures, while the Florentines have qualities of color and pictorial composition that are inseparable from the work of the great Florentine painters. Now, these differences, slight though they may possibly appear, are nevertheless of the very greatest importance, for they are immediate symptoms or *indicia* of the state of development or degradation of art forms. It is impossible to discuss here the matter at any length, but it is necessary to point out that the loss of feeling for the monumental and for space composition is invariably the mark of a falling-off in artistic sensibility and accomplishment, and that any art from which this feeling is absent is almost as by definition not only minor but provincial, no matter how charming or otherwise interesting it may be. The minor arts of any people imbued with this feeling for form speak with more authority of culture and strong and living tradition than even the greatest arts of a people that lack it. We have here a subject of the very

greatest importance, but one so much bigger than my present task that I cannot deal with it further except in as far as it will form the web of my argument.

In spite of the age-long trade that starting at Venice had found its way over the Alps and down the Rhine to the Netherlands, it was, after all, a very thin trickle of intercommunication. Germany and Italy were thinking about absolutely different things and had absolutely different attitudes toward life and its values. The little German cities that were fighting their political battles of particularism, the multitude of petty princes who kept the whole land in an armed uproar through their perpetual struggles for wealth and power, had reduced the Empire to a condition of economic chaos, and the seething interest in the doctrines and practices of the church had turned thinking men's minds away from everything but their theological wrangles. As has been noticed at other times and places laboring under similar conditions, when people think only of their pocket-books and of their religious observances, and especially when they mix up those two things, culture and the arts that grow out of it languish and disappear. Artistic and literary bankruptcy, except as mitigated by the emergence of a purely accidental personality, neither to be foreseen nor to be expected, had fallen upon a Germany that had lost all sense of political, economic, social, or spiritual unity or cohesion. If it is possible to judge in any way from Voullième's statistical analysis of the books printed at Cologne during the fifteenth century, the reading Germans of that time were interested in theology and the grammatical subjects of the medieval universities to the nearly complete exclusion of everything else. A neater demonstration of lack of culture than that provided by Voullième's table could hardly be desired. According to Mr. Pollard, the Germans during our entire period printed only two books by Germans that had any enduring merit—the *Parsifal* and the *Titurel*—both by Wolfram von Eschenbach, an early thirteenth-

century writer, and each in but one edition. It was not until the last decade of the fifteenth century that any books by living German humanistic writers were printed. The British Museum, the most representative, though not the largest, collection of early printed books now extant, contains more than twice as many works by classical authors that were printed by the brothers De Spira alone in the first four years of printing at Venice than were printed in all Germany during the entire fifteenth century. There can be no question that Germany imported classical and humanistic books from Italy in fair quantities, but this importation does little to offset the outstanding fact that those very good business men, the early German printers, saw so little chance for a profit in producing such books themselves. The most cursory glance through the pages of any history of the time will show the conditions of life under which the German people labored. There was almost no feeling that in any way or on any subject the people should pull together, or except in robbery, rapine, and theological animus should emulate one another. Germany during the first fifty years of printing presented a chaos that, with the exception of the previous fifty years, was one of the worst that modern European history has to record. It was not until the emergence of Luther, well after the close of our period, that for the first time since perhaps the Ottonian epoch there was any cohesive spiritual life in the land, any sense of a common interest in a common cause, and when that time came what happened was a cohesion into two armed camps, the misunderstandings between which were to remain the principal factors in German history until after the middle of the last century. And, as matter of fact, the *Anschluss* is still a burning question in all Central European politics and policy.

Germany was a splayfooted land, spread over a great territory, much of it in a condition but little removed from savagery, and with its local prides and particularisms so highly developed

that in spite of the wealth and economic power of several of the great trading towns it was doomed, until quite recent times, to remain what it was then, a land with no metropolitan center or centers, the stalking-ground of the stubbornest provincialities of all kinds. The result of this is shown by the fact that the slightest acquaintance with German picture-books enables anyone at sight to segregate them into the work of a large number of provincial schools—Cologne, Lübeck, Augsburg, Ulm, Strasburg, Nuremberg, etc. Every town in Germany had its local press just as it had its local prince or council and its local laws and custom-houses, and there was no centralizing artistic influence until after the close of the period we are considering, when Dürer's personality acted as a magnet for the lesser artists who came after him.

As a result of all this, fifteenth-century Germany was in no position to welcome or to take an interest in the new cultural ideas that had been developing in Italy for a century and a half or more, and that in the end were to alter the cultural life of Europe. So far from welcoming these ideas, Germany displayed a lack of interest in them that amounted to the stoutest of resistances to them, displaying a provincial stubbornness of the kind that passes for quaint, but that in reality is poverty stricken and stupid. The honest fact was that the Germans of that period had with few exceptions lost whatever sense of form they had inherited, and in as far as they were thinking for themselves were producing things of remarkable formlessness, chaotic and tangled and weak. When printing was introduced into Germany, not only was there no great living German literature or culture, but the German arts were at almost their low tide of formlessness.

The natural result was an enormous output of disparate, half-digested, formless things. Today, so long afterward and so far removed, we look upon the German books with a mixture of reverence and sentimentality that renders true appreciation

of them for what they actually were, and are, almost impossible. Their provincial quaintness renders them charming, just as provincial quaintness makes the furniture and the pottery of well-to-do peasants rather pleasant in our otherwise so highly sophisticated living-rooms. Our reverence for the inventors and carriers of printing, and our sentimentality for the things of far away and long ago, are too likely to blind us to the actual facts. Fifteenth-century German painting, sculpture, and architecture, like the German texts of that period, are, except for the Germans, provincial and minor, and German illustration of that time is a still more minor and incompetent reflection of those unimportant things. The very simple reason is that for the Germans of that time all those things were of the most minor importance. This immediately showed itself in their book design. It is all very well for sentimentalists to declaim their belief that early German books are the most beautiful of all books as well as the first; but were it true, it would be a miracle infinitely more marvelous than any of those recounted by the hagiologists. We cannot expect a people lacking in sense of form to produce great work in an art that, like pure typography, is entirely one of form.

The art of the miniaturist is always a minor reflection of the major art of its time, and, moreover, has only reached its apogee when in closest touch with that major art. Provincial work somehow never has the authority or the form that metropolitan art has, and just so much less has the provincial miniature. Book illustrations, being merely miniatures in another medium, are subject to the same rule of development. Now if we are honest with ourselves, we can see plainly not only how German illustration is inferior to that produced in Italy, the one great source of major art in the fifteenth century, but how in Germany itself the quality of the work depends upon its proximity to one of the greater German cultural centers. Bamberg, where the first illustrated books were produced, in spite of its great cathedral

erected two centuries before, was not a cultural center at the time those books were made—in fact, it was a very small provincial town, and its book illustrations quite naturally are rough, clumsy, uncouth, the work of men but little removed from the yokel, examples not so much of a new art as of the utter degradation of an old one. A little later there was an illustrated book produced at Rome—the *Turrecremata* of 1467—the work of German printers and German woodcutters. Its pictures are rough and coarse, but nevertheless they show plainly a sense of space such as had rarely been seen in any of the earlier German woodcuts, whether in books or in single sheets. Then almost simultaneously at Verona in Italy and at Ulm and Augsburg in Germany there came the starts of the flood of picture-books that has never ceased. Verona was hardly an outstanding center of culture but it was in close touch with the major currents of thought and opinion. Ulm and Augsburg were probably among the most highly civilized spots in the Germany of that period. The differences between their books and the Bamberg books and that of Rome are immediately perceptible. Such books as the Ulm Boccaccio and the Augsburg *Speculum* when compared with the Bamberg *Edelstein* are the work of cultured people, but as against the earlier and technically cruder Roman *Turrecremata* there is no disguising the fact that they in turn lack authority. At that time Rome was not a great artistic center, but even so it was so much closer to the cities where great art was being produced that it brought forth something of a finer kind. At Verona in 1472 there appeared an edition of Valturius. Technically in the same primitive group as the Bamberg books, for its cuts and its type were printed separately, it is artistically in a group all by itself, its wood blocks speaking with an authority and a sense of form such as few if any German books of any period or place have ever exhibited. It was the first illustrated book printed in Italy that was made throughout by Italian hands, and the Italian culture and defi-

nite, clean-cut attitude toward life and art showed themselves in it beyond any misapprehension. Its pictures, not by a great artist, nevertheless are fully in a great and a highly civilized tradition, for immediately back of them lie the personalities and achievements of such an able man as Matteo de Pastis and such a great master of form as Pisanello. And what is true as between these earliest groups of illustrated books remains true during the rest of the fifteenth century. The German book only breaks out into something of great importance or genuine artistic interest when, as in such a volume as Dürer's Apocalypse of 1498, it shows the hand of no minor craftsman but an artist of true personality and individuality, of some man so gifted that notwithstanding his provinciality he was able to project something of his own great and peculiar character on to the pages that he decorated. Italy produced few if any definite personalities among its book-illustrators prior to 1501, but their expression and their cultural tradition carried them far beyond anything that was known north of the Alps, aside from the work of the two or three greatest German personalities.

There is nevertheless a small group of German book illustrations that stands out from the formless ruck by virtue of the fact that their blocks happened to be cut by comparatively careful woodcutters, who, to a certain extent, respected the linear quality of the drawings on the wood, and in so doing preserved for us some *indicia* of the personalities of their illustrators. This does not necessarily or in fact mean that these particular illustrations were better drawn or had any greater pictorial merit than the others, for few if any of them have any definite artistry behind them; it means only the accident of comparatively good cutting. Few of them were comparable to the drawings that the Italian and French and Dutch woodcutters so cheerfully mangled without being able to impair their essential structure and pictorial composition. In almost every one of this small group, thanks to the woodcutter, it is possible

to discern the existence of a definite person as draftsman—that is, we feel sure that each of them was illustrated by a real man and not by a hand in a shop, by John Jones and not by Jones & Co. It is to be observed, however, that this personality except in two or three cases is never that of a great or even of a really able draftsman; it is no more than the very little that is needed to distinguish a man from his fellows. How little this is we may see by the fact that the *Breydenbach* of 1486 and the *Schatzbehalter* of 1490 are included in every list of important German books, one the work of Erhard Reuwich and the other of Michel Wolgemut. Reuwich was an unusually traveled artist, who had been not only to Italy but on beyond to Egypt and the Levant —facts that imply that he was one of the few German artists of his time who had come into contact with the greater art of the world. And yet in spite of all these advantages what a low rating he must be given in the artistic hierarchy! That one so poor should have been one of the outstanding figures of his time is a commentary that needs no laboring. As we know little of Reuwich, so we know much of Wolgemut, who was one of the prominent artists of Nuremberg, the head of a flourishing school of painters and illustrators, the draftsman chiefly responsible for the celebrated and well-known *Nuremberg chronicle*, and for a while the master of an apprenticed youth who subsequently was to become the most important of all German painters, Albert Dürer. From Wolgemut's studio there came many paintings, a large number of which are still in existence. A rather unusually big one is in the Museum of Fine Arts in Boston, where the curious may see it and speculate as to the reasons why such an ungifted, scatterbrained man could be ranked among the greater artists or illustrators of his day and country. Any society, any culture, in which these two men could stand forth was, almost as by definition, backward, provincial, clumsy, and ignorant.

The three books that stand out from all the others in fif-

teenth-century Germany for the real personality that lies back of their illustrations are the *Ritter vom Thurn* of 1493, the *Narrenschiff* of 1494, both printed at Basle, and the Nuremberg edition of the Apocalpyse of 1498. The Apocalypse, which bears in its every line the impress of the power of Albert Dürer, was the last and by far the greatest of all the German fifteenth-century illustrated books, the culmination of all German Gothic pictorial art. It is so famous and so familiar that it is not necessary to discuss it. The two other books have been ascribed to Dürer on the basis of style criticism, and there seems to be every reason for believing that he was responsible for all the cuts in the *Ritter vom Thurn* and many of those in the *Narrenschiff*. Designed by him in his early twenties (he was born in 1471), they are of great historical interest, but I cannot rid myself of a most sincere doubt that they stand out far more because of the general poverty of the books surrounding them than on the score of any very great positive merit of their own. The reason for the vast and overwhelming superiority of the Apocalypse of four or five years later is to be sought not so much in Dürer's natural growth into a German maturity as in the fact that he had in the meantime sojourned in Venice, where he had come into contact with some of the greatest painters of the Renaissance and had studied and learned many things that could never have been discovered by him had he stayed in Germany. He had come for the first time into contact with great and metropolitan art as contrasted with the things that he had known in Germany, and the experience had completely changed him.

The remaining German books, good or bad, all fall into the great group the illustrators of which are utterly unknown. The best of them—those, that is, in which the cutter did not destroy the personal quality of the lines—constitute a curiously mixed lot. One of the most interesting of them is the Lübeck Bible of 1494, the anonymous illustrator of which certainly drew most

of the woodcuts in the celebrated Lyons Terence of the previous year. It is probably fair to conclude from this other book of his, Lyons and Lübeck being so far apart, that he had traveled, and had come into contact with the greater things of the artistic world. In any event his drawings for the Bible speak with a more certain authority and out of a more definitely formed artistic understanding than those in any printed book produced before their time in Germany. Up to then there had been no such power of draftsmanship shown in any German book. His figures have weight and muscle, their gestures and positions are sharply observed, and there is a very definite sense of pictorial composition that is not to be equaled even in the two early Dürer books. He stands out easily as one of the greatest graphic artists that fifteenth-century Germany can boast, an artist of far greater accomplishment than all but such rare engravers as the Master E. S. and Schongauer, and second to none of the designers of woodcuts. In Lübeck they say he was Bernt Notke, but I am not aware that he has been really identified or his work authoritatively attributed to someone known through other activities such as either painting or engraving.

Two books of quite different character and obviously not by the same hand have been attributed with great show of science and learning to another artist, the anonymous "Master of the Amsterdam Cabinet," or, as he is also called, the "Master of the Housebook," who was the earliest man to produce an engraved *œuvre* almost if not entirely composed of what we now call "dry points." Whether or not he had anything to do with either of these books is more or less immaterial as the books speak for themselves and are unquestionably to be thought of as the culminating points of the second group of German illustrated books. One of these is the *Spiegel menschlicher Behältnis*, printed at Speier by Peter Drach about 1479. Two earlier sets of illustrations for the same text had appeared, at Augsburg in 1473 (in Gunther Zainer's Latin version) and at Basle in 1476

(in Bernhard Richel's German version), and a comparison of the three shows what a great step forward in liveliness and power of representation had been taken by Drach's unknown artist. His cuts are designed without any particular thought of their effectiveness as pictorial compositions, and their line is definitely of the kind loved by calligraphic draftsmen of all periods, full of meaningless crinkles and small flourishes. Their chief merit, aside from their liveliness, is to be sought in their evident reflection of a humorous and idiosyncratic personality. The other book, undated but of approximately the same date, is the *Spiegel des menschlichen Lebens* printed by Gunther Zainer at Augsburg. A second edition, printed by Baemler in 1479, contains the same cuts. This series of illustrations, at least to my eye, is to be regarded as the high spot of German illustration prior to the Lübeck Bible and the Dürer Apocalypse of twenty years later. Their draftsman was almost the only one of the early German designers of woodcuts whose work is marked by thorough command over the simpler and more immediate problems of draftsmanship. His convention of representation is delightful, and he knew how to use it in such manner that both representation and composition were afforded their respective importances in his little pictures. Minor as they are, they have back of them a tradition of something more than is to be found in any of the previous books—an elegance that sets them apart from almost all the German books of the fifteenth century.

Anton Sorg, of Augsburg, has a great reputation for the illustrated books that came from his press, but this reputation is based in largest measure upon the large number of such books that he issued. Their quality is not comparable to that of the volumes produced by the two Zainers, at Augsburg and at Ulm, and to an important extent they are debased copies of the Zainer books. Their charm, such as it is, is to be sought primarily in their painting, for most of them had their woodcuts cheerily and gaudily daubed up with simple and childlike pig-

ments. Sorg's only book that calls for more than a passing glance is Suso's *Der Seusse* of 1482, the large cuts in which have a certain naïve and clumsy decorative value.

The remaining group of fine illustrated books is that produced at Ulm by Johann Zainer. Of these, the best, it seems to me, are the undated *Griseldis* (of about 1473), Boccaccio's *De mulieribus claris* of the same year, the Aesop of 1476, and (if it be by Zainer) that *Geistliche Auslegung des Lebens Jesu* which has been attributed to most of the more important German printers over a period of more than twenty years. The *Griseldis* is as rare as the Boccaccio is comparatively common, and seems to have been done by the same hand and was certainly done in the same manner. The Boccaccio cuts are spirited and full of life and movement—much better pulled together as compositions than all but very few of their contemporary illustrations—and have had the great good fortune to have been greatly liked and frequently mentioned by William Morris. They have the merit, if merit that be, of fitting very well and very decoratively into their type pages. If illustration were an applied art of decoration and not a fine art of expressive draftsmanship and pictorial composition, then there can be little doubt that they would take very high rank among the greater illustrations of the world. The drawings in the Aesop have not the same decorative value, and neither are they as well composed, being rather of the nature of marginal sketches than full-fledged pictures, but they have a pleasantly canny skill of representation of movement and gesture that bespeaks a much more talented draftsman than the artist of the Boccaccio. The pictures in the *Geistliche Auslegung* are of quite a different stripe than those in any of the Augsburg or Ulm books that we have discussed. Not so well drawn as those in the Aesop and not so decorative as those in the Boccaccio, they come nearer to being real pictures than anything to be found in any other Ulm book. When well colored they have a certain power and impressiveness that

lift them out of the class of mere picture-book illustrations into a finer and rarer group.

Honesty has compelled me to talk thus frankly about the German illustrated books. They were those that I knew first and most intimately, and I still have a love and a romantic reverence for them that all my admiration for the Italian books has never been able to weaken. But with all the best will in the world I am unable to give you any other account of them than that which you have heard, for to acclaim them as great works of art would be to play traitor to intelligence and to experience. German illustrations, except for the miracle of Dürer, are the minor pictorial product of provincial and minor schools of art, and their personal and local idiosyncrasies, however much we may enjoy them, cannot turn them into anything else.

Italy during the fifteenth century was beyond any question the intellectual and cultural and artistic metropolis of the Western world, and had discovered, and developed, and gone through an incredible number of things that the north as yet knew nothing about. In the central and northern Italy of the Renaissance, torn and disrupted as that country was by personal ambitions and military feuds, there was always in some curious way a spiritual homogeneity, an artistic emulation, and an awareness of a great tradition. In spite of their squabbling there was a more or less centralized, directed, intellectual, and artistic endeavor, which went on undisturbed by the political Donnybrook fair. The princes and the republics vied with one another in their ostentation and their fostering of the arts—led to it, perhaps, by their desire for glory, a thing that they thought of in the most practical and material ways. Moneylenders and captains of mercenaries gave more thought to the celebration of their glory than all of Germany did; a Malatesta, become lord of Rimini, calls in Leone Battista and Matteo de Pastis to design and decorate a chapel in commemoration of himself and his Isotta. And what this little *condottiere* does on his small

scale, the great lords and bankers and the municipalities and the chapters do on their much greater ones. The result was the development of an artistic ferment that called to its service an incredibly large part of the genius of the land, and it was not long before there was a repetition of the phenomenon that had previously displayed itself at Athens and at Constantinople. Florence and Venice took to themselves an artistic hegemony, brought together into intercourse and emulation the greatest artists of the world, and through them and their work in time set the fashions and the artistic beliefs of the world. They provided intellectual, artistic centers of a kind that Western Europe had not known, at least since the break-up of the Empire, and that dominated by their concentration and direction the rest of the Continent. Where the Germans were fighting and being different from one another, the Italians fought and emulated one another. Instead of being proud and content with their little local artists, they did their best to entice the great artists from the service of their enemies into their own.

Into a country and a spirit of their kind printing was introduced, and though brought down across the Alps by Germans who entered the service of a Spaniard, it was impossible for the new invention not to take on the color and the shape of its surroundings, or the culture it was called upon to serve and to be subservient to. The earliest Italian book that has come down to us, and as far as we know there were but one or possibly two that actually preceded it, has already a look and a feeling for form and elegance that no book printed north of the Alps was to have for several generations, and possibly never at all. That this book should have been a Lactantius, the Christian Cicero, rather than a Bible or an ordinary theological book is in itself a symptom of greatest importance for anyone interested in comparing the Germany and the Italy of the day.

Where the history of German printing is the history of a handicraft plied in many places, the history of Italian printing for

practical purposes is the story of what happened at Venice and at Florence, for just as those two cities had become the artistic metropolises of the peninsula, so did they shortly become the great centers of the Italian publishing business. Rome, Verona, Naples, Ferrara, and many other towns produced books, but in the event it was at Venice and Florence that the great output was made, Venice becoming by all odds the greatest manufactory of books in the world, drawing to itself the best and the ablest and the most learned printers from all the other countries. That Italy should so soon have effected such a concentration in the printing trade does more than any amount of statistics and learned investigation to prove the extent to which Italy in reality enjoyed a homogeneity of culture and interest. To compare the artistic importance of Strasburg and Nuremberg and Cologne, the greatest of the German printing centers, at any time in their histories with that of either Venice or Florence during the period from the introduction of printing down to the end of the fifteenth century were rankest folly, and to display only a wilful blindness to hardest fact.

Before discussing the illustrations produced at these two typographic capitals, it is necessary to refer to several books printed elsewhere. I have already spoken of the Roman *Turrecremata* of 1467 and the Verona Valturius of 1472 and do not need to call attention to them again. After them comes the Verona Aesop of 1479, the cuts in which have not met with the approval of one of the greatest of all students of early picture-books. It is perhaps presumptuous in me to disagree with Mr. Pollard, but the fact is that where he sees only clumsiness in this book I see something more, a dash and verve and an inventiveness rare enough at any time, and in addition a direct affiliation with the great art and tradition of the day. It was the first, and until quite recent times the last, book to be illustrated with woodcuts conceived not as imitations of pen drawings but in immediate terms of knifework upon the block, and thus shows an inven-

tiveness that lifts it into the class of the great precursors. I should like to believe that these pictures were cut by their designer, a thing that is almost impossible to believe of any other fifteenth-century Italian book illustrations, for in no other way can I account for their peculiar and direct quality. One can attach no name to their draftsman, certainly he was not a great master, but I know of no other illustrations like these—to me a sure sign of personality. Incidentally, it is the first book to contain a long series of borders constructed from typographic flowers, and was thus the starting-point of one of the great avenues of artistic printing endeavor. The other great pre-Venetian Italian book is the Naples Aesop of 1485. It was made in Italy, but Naples at that time was in the hands of the Spaniards, and though printed by an Italian it was illustrated by someone whose handwriting shows indubitable traces of Spanish habit superimposed upon a Teutonic foundation. There are three traditions visibly working in its cuts, and working at cross-purposes. The decorative borders are Iberian, the feeling of the lines is German, the figures are Italian. Arresting in their startling black and white, and interesting for their Hispano-Moresque pattern, these woodcuts have always enjoyed fame and renown. If I may, however, again be permitted to interject the first person, I cannot bring myself to think that they are as noteworthy works of art as those in the thoroughly homogeneous Verona Aesop, not only because I am bothered by their half-breed design, but because they nowhere exhibit the same vivacious and sparkling sense for an order and pattern that grows naturally out of the conjunction of subject matter and technique. The man who designed and cut the trees and the peacocks and the notation of distant hills in the Verona book had not only a lively invention but a most decided sense for style. And again it comes back to that matter of artistic sensibility and tradition which I have so much labored.

Now, returning to Venice and Florence, I shall talk about

Florence first, although its earliest illustrated books are much later than those of Venice and much fewer in number. In certain ways, also, they show much less divergence from a centralized type, and, furthermore, they had comparatively little influence upon woodcut design in other places. In spite of all that, they illustrate my central thesis in the most remarkable way—their pictures are not only the loveliest to be found in any early books, but they are more closely allied to and based upon the contemporary painting design of a great school than any of the woodcuts produced before the outstanding masters of painting themselves took to designing book illustrations. If I am correctly informed, there are no signed early Florentine woodcuts and no contemporary document that throws any light upon their makers. My dear friend Bernhard Berenson about thirty years ago attributed a great many of them to Bartolommeo di Giovanni, but I am certain that neither he nor anyone else will find much fault with the person who prefers to think the case unproven. Even more than that, it seems to me quite impossible to take any groups of these Florentine illustrations and say, as we can so definitely with a number of the German woodcuts, that they are by one particular man whether or not we know his name. It is not even possible to segregate them into workshop groups. And thus the Florentine woodcuts present the most complete possible anonymity, an utter lack of that stamp of personality which, as we have seen, was the feature of the German cuts that more than anything else redeemed them from barbaric commonplaceness.

As against all this, what have the Florentines that other woodcuts have not? A glance through any haphazard group of them shows immediately several technical peculiarities of the greatest importance. Aside from a comparatively small number, and most of those of the earliest group, the Florentine cuts are inclosed within borders of black relieved by incised repeated motifs—leaves, lozenges, etc., of exactly the same kind that the

Florentine architects and cabinet-makers loved to put in bands upon their various constructions. These woodcuts are thus framed in the same way that their contemporary pictures, wall panels, and carpenter's furniture were framed, in accordance with a convention that had been generally adopted at the greatest center of artistic activity of which we have any knowledge in modern times. Further, the color of the woodcuts is enhanced by a bold and daring use of solid blacks not to be found elsewhere in European work. Sometimes these blacks are relieved by a system of white scratches, and not infrequently the lines of representation are carried across them in white line. The Florentine cuts thus present the only group of old woodcuts not only in which black was used pre-eminently as a background color but in which the drawing was carried forward in both black and white. It was a device that produced a richness of color elsewhere unknown, making possible a species of "counterpoint," if that is the correct word, common enough in painting but hitherto unknown in black and white. It was distinctly an invention of a kind that seems never to be made except in a community that has a long and a distinguished artistic tradition behind it—distinctly a metropolitan device and not a provincial one. To handle it without coming to grief was something that was not in the power of anyone not possessed of the easy and comfortable assurance that comes only from a highly developed and centralized culture. In addition to these two matters of framing and color, both of which, as we have seen, spring from definite artistic consciousness and singleness of purpose, there is a final aspect of these Florentine cuts that is more important still, not only because it arises even more definitely out of the cultural background but because it is of greatest worth in itself. This is the pictures themselves. Where the German woodcuts are usually rather splayfooted drawings, careless representations of things and of men and animals in action, these Florentine prints of the time of Botticelli are full-

fledged pictorial compositions in which all the elements, in addition to their representational interest, have the added merit—a merit so great that it is difficult to overrate—of having definite compositional relationships to one another. One might almost say that this more than anything else was the final touchstone of a culture of form and balance, in which the relations between things have been recognized as being of equal if not greater importance than the things themselves. In fact, it might possibly not be too much to claim that as long as things are seen disparately in themselves and not as existing only in their relationships, in the patterns they make with other things, that there is no real culture. From this point of view there has never been any group of European woodcuts, unless possibly some of those made in France during the nineteenth century, that is comparable to those made in Florence during the brief period of less than twenty years through which the Florentine woodcutters were actively at work.

The secret of the Florentine composition, that careful balancing of parts against the whole and of the whole against its parts, can be sought for only in the close relationship that existed between the designers of the woodcuts and the great painters of the day. Although the hand of none of the outstanding or important Florentine artists can be traced in a single woodcut, there is not a single woodcut that does not reek of their presence, their lesson, and their leadership. Without Botticelli and his great fellows these minor works of art could not possibly have existed, and neither could they have existed had the teaching of those great masters not been absorbed until it had become an easy and a comfortable rule of life and action in which the lesser men could work without distraction and without being at cross-purposes with themselves. If their work when seen *en masse* has a tendency toward the dulness that comes from lack of the unexpected, it can only be said that that particular and rare kind of dulness is only to be found in works of art, litera-

ture, architecture, and music that are possessed of great style, in which harmonious balance is of the essence. Complete freedom from that dulness is only to be found in the work of men unhappy and at war with themselves, full of contradiction and uneasiness—that is to say, of men who do not know what they want to do, who are unwilling or unable to make sacrifices necessary for coherence, and who are usually to be found in provincial communities fighting for their local particularisms in ignorance or antagonism to the metropolitan thing.

Of the Florentine books themselves it is almost impossible to make any particular choice, those that stand out doing so not because their cuts are conspicuously better than any others but because they happen to contain more of them. Had one to pick just one and no other, choice would doubtless fall on the *Epistole e evangelii* of 1495, and for no other reason than that it is the most profusely illustrated of all. There can be no question that it is one of the greatest illustrated books of the world. With few exceptions, the Florentine picture-books are small in size, many of them sermons, tracts, and librettos of popular performances; the kind of book that is issued on an occasion and to reach its fullest use and audience must be adapted to easy handling and easy reading. Typographically they are not distinguished, but they have one singular merit which sets them aside from most of the other books of their time: they are actually easy to read. In view of the fact that a large proportion of them were issued not for learned libraries but as propaganda in one of the most stirring and dramatic revolutions and civil wars of the Renaissance—put forth with the deliberate, thoughtful intent of making the people read them whether they wanted to or no—we should not be terribly far from the mark were we to regard them as the first large group of books the makers of which realized and adapted themselves to the physical conditions which in the event have produced the modern book. Of one thing, and it is a thing of vast importance, the Florentine

publishers gave a most marvelous and complete demonstration —that to be noteworthy and memorable as work of art it was not necessary that a book be either big, or odd, or expensive. No more modest or simple picture-books than these were ever printed and none that have greater charm. Their very simplicity and ease and normality lead one to ask the question whether any book that lacks those qualities can ever be a very fine one, and candor compels one to say that a surprisingly large proportion of the really very fine ones owe more than a little of their greatness to just those qualities. The big book, the book that is queer or outlandish, the book that is obviously expensive, the book that has had overmuch care bestowed upon it, that has sojourned too long in the beauty shop, must always be somewhat more than suspect in the eyes and thought of honest gentlemen. Self-consciousness and the deliberate desire to impose are as bad manners in books as in men, and the printer who intervenes in his vanity and his airs, either high-falutin or of grandeur, between reader and text or picture convicts himself of unfitness for society. The best printer is he whose work is least visible, most transparent, least arresting; the best book that from which the reader turns with the fullest memory of text and picture and the least recollection of typography. Of all this the tracts of Savonarola are living witnesses whose testimony cannot be gainsaid.

The Venetian story, although that of a single city, is, in its importance as against the future, the most important of any in the history of fifteenth-century printing. The art of casting types was doubtless invented in Germany, the first illustrated books were made there, the first Roman letters were designed by a citizen of Ulm; but the German book, lacking the balance and clarity of the Italian book, made by and for communities distinguished rather for their local, provincial particularity than for their enlightenment or culture, never achieved international currency and, even right into our own day, stubbornly resisted

the changes and developments out of which have come the modern book. Their particularism becoming a matter of patriotic pride kept the Germans and their books from ever swinging into acceptance of the great Western European form, and more than that, it stifled such seeds of progress and invention as lay dormant in them. Their particularism could only be maintained by as resolute a refusal to change and growth as possible. In Italy it was different, and especially at Venice, that greatest of all entrepôts and international meeting places. There men of every nationality, race, and culture intermingled with a curious freedom and the most avid of interests in one another's ideas and wares. It was the crossroads of the earth. Independent, wealthy, Byzantine, Italian, its native culture was strong enough and deep seated enough to absorb all these various strange elements, to turn them to its own good purpose, and through them to be not only in touch with but a great deal in advance of almost all the rest of the world. Its bankers and traders had intimate relationships with every land and every people from the Atlantic to the Euxine, and it held in fief not only large parts of Italy but islands in the archipelago and parts of Greece. When the Eastern Empire finally fell it was through Venice that most of the exiles reached Western Europe. Of all the places in the Christian world in the middle of the fifteenth-century, Venice was the only one where ideas and tolerance were to be found in the market place.

Printing was introduced into Venice in 1469 by John of Speier, a German. The next year Nicholas Jenson, a Frenchman, produced there a book in the Roman type that has long been recognized as one of the handsomest that has ever been made. The first book in a Gothic type to come from a Venetian press did not appear until 1473. Significant as are these facts, they gain additional importance when we remember that before long Venetian printers, reaching out like other Venetian merchants for sale of their wares, had produced books not only in

Greek and the Balkan and Armenian tongues, but had produced missals of uses as far asunder as Sarum and Cracow. All Europe was their market, and to make it so they had to compete against all the local printers of Europe. In such a situation particularism was impossible, and wares to be sold abroad had to have definite advantages over those produced in the places of sale. It was imperative that the Venetian printer address his mind and skill to clarity, utility, and progress, and in doing so he was immeasurably aided by his long background of definite metropolitan culture. The result was that while competing with other places for the trade of less cultured communities, and in so doing continuing in part to produce backward books, Venice took most of the steps toward the evolution of the modern book, and by the end of the century had so altered much of its output in response to its discovery of the fundamental functional and physical problems of use that it had not only produced a modern-face roman type but italics, and the first edition of a great text that could with ease be held in one hand or carried in a coat pocket. If printing was born in Mainz, it grew up and was educated and learned its profession in Venice, and there also first demonstrated its maturity. If the baby was German, the man was Italian. At no other place than Venice could so astounding a transformation have taken place.

Sometime in the middle years of the fifteenth century, or at least so it is said by the learned, for in this kind of thing we must remember that learning only thrives in the presence of ignorance and vanishes with the advent of definite knowledge, a block book was produced in Venice. If also, as the learned intimate, it was designed by Jerome de Sanctis, whose illustrations in the Sacro Bosco of 1488 were the second set of illustrations that are both dated and by a known man, then was he the first to produce a set of printed book illustrations, for the two earliest German names are those of Friedrich Walther, who produced the Nordlingen block book of 1472, and Erhard Reuwich,

who illustrated the Mainz *Breydenbach* of 1486. Until the dating and attribution of this Venetian block book pass from learning over into knowledge, there is every reason to favor the probability that this great artistic adventure took place in Venice.

However all this may be, there are Venetian books of 1471 and 1472 the borders in which have been stamped in after the printing was finished. The earliest dated Venetian book to contain printed illustrations came out in the year 1479, twelve years after the first such Roman book, and eleven before the first such Florentine. In 1485 Erhard Ratdolt, then at Venice, issued the Sacro Bosco that contains the earliest woodcuts (in this case diagrams only) to be printed in three colors. In 1488 De Sanctis put his name to the pictures in another Sacro Bosco. In 1489 there appeared from the press of Co de ca a little pocket-size *Meditations on the passion* containing eleven delicate woodcuts, spirited and full of figures. The cuts in this book are by two different hands, one of whom with some reason has been identified with the Paduan miniaturist Benedetto Bordone, whose work shows clearly the immediate influence of Mantegna and the Bellini. The next year, 1490, there was published an illustrated edition of Mallermi's vernacular version of the Bible, that contained no less than three hundred and eighty-seven cuts by these same two hands. The Germans have always claimed that these Bible cuts were copied from those in the celebrated Cologne and Nuremberg Bibles of 1479 and 1483. As a matter of fact, all that they do is to represent the same incidents in the sacred story. But even if they had been based upon the German cuts, they are in such a wholly different and finer class that there is no comparison between them, the influence and tradition of Padua and Venice being of such a very different caliber from that of Cologne. After that comes such an efflorescence of illustrated books as no other Renaissance city and few Renaissance countries can match either in number or (with the exception of Florence) in quality.

It would be impossible here to recall the names or the designs of more than a very few of these books, and so it must suffice to point out some of the characteristics of the more noteworthy groups among them. Elaborate and fine as were the borders produced at such German towns as Cologne and Lübeck, and at Paris, nowhere else in the fifteenth century was such an array of beautiful borders produced as at Venice. Those that appeared in the books issued by Ratdolt, with their handsome combinations of natural and classical motifs in white against black grounds, in the full Renaissance style, are peculiarly interesting, not only for their own merit but because after Ratdolt left Venice and went back to Augsburg he ceased to use them although he had taken with him most if not all of his printing material. Whatever the immediate reasons for this may have been, accidental or otherwise, the fact that he did not use them thereafter or replace them by others of the same kind goes far to show the German particularist resistance to the metropolitan thing, the typical German discomfort and unhappiness in the presence of disciplined form and the sacrifices of petty personality that it necessitated. Perhaps the two handsomest of the great Venetian borders were those that appeared in the Ptolemy of John of Königsberg and the Herodotus of 1494. The latter is, in its elegance and brilliance of both color and line, perhaps the most astonishing of all borders in the Renaissance style. Certainly in more modern times it has been more looked at and more emulated by designers for the press and for advertising purposes than any other. Like so many of the other Venetian borders, it is based immediately upon the designs of the architects and stone-carvers for the decoration of flat surfaces, and thus displays a relationship to monumental art of a kind that is seemingly all but unknown north of the Alps. Its merit is thus singularly dependent upon the influence and the discipline of a major art of form. This border is further of interest because in it is to be seen one of the most typical examples of the skill

of an unidentified but clearly recognizable artist, to whom we owe several of the most remarkable of all Venetian picture-books. It is sufficient here to mention but two of these, each of which in its way was destined to become one of the greater sources or carriers of design. The earlier of these, the Ovid of 1497, became the favorite pattern-book of the makers of the elaborately painted and decorated Venetian marriage chests and of the painters and decorators of the *maiolica* dishes that are among the loveliest and most charming of the minor works of industrial art of the Italian Renaissance. When trying to run down the source of the design on one of these dishes, almost the first thing that one does is to turn through the pages of the Ovid. The other book is the so celebrated Aldine *Hypnerotomachia Poliphili* of 1499. It would be possible to name but few objects that have had the influence on subsequent design that this book had. In Venice and Italy it had little popular acclaim, its text too erudite and its illustration too familiar in type and style, to arouse much interest. It took forty-odd years to sell off its first edition of six hundred copies, and with the possible exception of the *Nuremberg chronicle*, which was too big to be read or used, it is today the commonest of fifteenth-century books. In the year of its second edition, 1546, a translation of it into French, accompanied by French copies of the woodcuts of the original, was published at Paris. This translation went through four or five editions, the last of which found a market after the beginning of the seventeenth century. It is doubtful whether any one set of designs has ever played so extraordinary a rôle as did this in the conversion of France from its Gothic to its Renaissance. It was the first and the greatest of the printed carriers of the revived classical feeling to the peoples of the north.

The *Hypnerotomachia* thus immediately raises several questions that are of extreme importance in any critical discussion of book design and illustration. As far as its text went it was an

impossible, erudite, silly romance, fittingly written in a jargon that is almost macaronic, devoted in largest measure to abstruse symbolism and the maundering of a mad collector of classical remains. It describes, as only an Italian platonic humanist could, temples, groves, palaces, ruins, gods and goddesses, and fragments of ancient art. In parts it reads like an imaginative museum guide. And it was illustrated with pictures of many of these things. Thus it happened that within the covers of this crazy book were to be found more representations, clear, lucid, and simple, of the architectural and monumental forms that intelligent Italy had evolved from the classical, than had ever before been printed. In its time it was the first treasury of what the people north of the mountains regarded as the new Italian styles, and as such it was, when it reached them, fastened on with avidity, studied, translated, and copied. Anything further from the minds or intention of the author and illustrator could not be imagined. A richly illustrated book, filled with outline drawings of architectural motifs and details, vases, capitals, arches, pilasters, and other such things, it could not well escape being itself a rather effective object. Short of deliberate malicious intent and skill it would have been difficult to create out of this material an ugly or a formless book. Its draftsman was anything but a great artist, but its subject matter and the traditional technique in which he worked lent themselves most admirably to the creation of a homogeneous object of art. Between its letter press and its illustration there was no conflict of color or linear form—a result purely accidental, possible only because the draftsman lacked personality and his subject forbade it. Its success from the typographic point of view is grounded in the fact that its figures display almost as little personality or color or draftsmanship as those in a Euclid. The result is that by many in these modern times it has been declared to be the most beautiful of all illustrated books.

Now this leads us immediately into a discussion of certain

things that I have already referred to, but which need further attention and consideration, because a clear understanding of them is required for any critical judgment of a matter that lies at the very basis of the problem of book illustration. It all starts with the question, What is a book for? What is the purpose of a book? Now it seems to me that this question has been greatly obfuscated by the artistic printers and by people who have been willing to accept their expert opinion. The primary purpose of a book is to be a conveyor or container of words and pictures. The type and arrangement and size and weight are all supplemental, subservient, incidental matters. Words and pictures may be matters of great moment, expressions of all that is finest and most wonderful in the development and experience of the human spirit. Type, arrangement, and all that, at best, are but matters of convenience, at worst but an occasion for the exercise of interior decoration. If we judge of the merit of a picture by how it fits the place where accident has brought it, or the merit of a poem by how beautifully the compositor has set it up in type, or the merit of an illustration by how inconspicuously and comfortably it sits in its surrounding letter press, why, then, there is ground for the doctrine taught by Morris that pictures in books were good or bad as they were in harmony with the type face and the type page. The mere fact that Morris thought that books should be judged not by their literary or artistic content but by how they looked when seen two pages at a time, i.e., in a way in which it is impossible to see what either writer or artist has done, and to see only what the interior decorator has done, it seems to me should be sufficient answer to the validity of his teaching. It is notorious that interior decorators are not interested in fine art, in the things that are expressions of the soul and spirit of men. If we are to judge of the merit of picture-books from the interior-decorator point of view, it can have only one result, that the merit of a book will be found in its layout and typographic arrangement and not at

all in its spiritual or useful content—a situation that to my mind at least is abhorrent as representing a complete upsetting and bankruptcy of all spiritual values. A great book is a book that contains either great words or great pictures; without them it can be only a piece of furniture, no matter how exquisitely, pedantically, or meticulously it is joined together.

For many years there has been no discussion about the relative importance of great texts and so-called "fineness" of printing; the two things are never confounded in thought. Shakespeare remains Shakespeare no matter by whom or how printed. On the artistic side, however, there has been the most marvelous of confusions; people have insisted on regarding illustrations as matters of interior decoration instead of as works of fine art. The little pictures in our books have been judged as though they were mere furnishings and not expressions of men's souls, as though they were subsidiary to the looks of a book seen two pages at a time, instead of being one of the two fundamental reasons for the very existence of a book, one of the two things which everything else in a book is but a mechanical contrivance for containing. One hears many people say that they dislike illustrated books, but the reason for that is that they have been acquainted only with books in which the illustrations have been either stupid or degraded to the position of furniture. It is a curious thing and one worth thinking about that so very few of the greatest of illustrated books—those containing pictures which on their own account are great or memorable works of art—have been what are now generally recognized as fine books. In all the great array of wonderful black and white with which the books of the last century abound, none occurs in a book that the fanciers of typography ever speak of as a fine book. To speak only of English books, what collector of fine books ever thinks or speaks of Thornton's Virgil, of Moxon's Tennyson, of Rossetti's *Goblin market*, or of Dulcken's *Arabian nights?* And yet they contain the finest pictures in black and white

that England produced in the nineteenth century. And so, I beg of you, is it not possible to bear this kind of thing in mind: to distinguish in thought and talk between the books that on the artistic side, as distinct from the literary, contain fine pictures and those that are merely striking pieces of furniture? If we could all do it, it would not be long before there would be a very extraordinary revaluation of the merits of our picture-books, or before the people would discover that in picture-books is to be found one of the greatest sources of true artistic and aesthetic adventure.

But it is time and more that I descended from my pulpit and returned to the story of the fifteenth-century picture-books, about which I may remark, in passing, that almost without exception the finest of them from the point of view for which I have just been pleading are among the greatest rarities for the very simple reason that they were read and used out of existence.

Among the most delightful and typical Venetian books of this time are the two Aesops, the *Life* and the *Fables*, which are especially of value in any such discussion as this because the illustrated editions printed at Ulm, at Verona, and at Naples are among the finest books of the period. There was also a Florentine edition, but unfortunately I know of no copy on this side of the Atlantic, so that it is impossible to bring it into comparison. The Venetian editions show very definitely the dependence of the illustrator and book-decorator upon the local monumental art, the large and elaborate borders on the early pages and the smaller passepartouts in which the cuts are framed being immediately inspired by architectural and sculptural schemes of decoration. They are not impossibly to be rated among the finest of their kind.

There is a number of large borders that appear again and again in various books, such as the histories that were so popular at this time. Constructed in immediate dependence upon

the great Renaissance tomb sculpture, these borders may, with a fair-enough approximation to accuracy, be regarded as the most typical Venetian contributions to Renaissance book decoration. In any event they were the most copied, the designers and printers of the immediately succeeding generations in Switzerland, at Lyons, at Paris, and in various Italian towns finding in them the patterns upon which they based a very large proportion of their own initial borders. Among these designers was no less a person than Hans Holbein, a number of whose more youthful performances are derived directly enough from these Venetian precedents. It would be an easy task to bring together photographs of some of the tombs, a Venetian border of the same compositional character, and a series of the non-Italian borders based upon it. The shifts and changes that take place as the design travels provide not only a simple and easy way of comparison between the distinguishing traits of the various artistic schools, but a most definite demonstration of my thesis that the quality of book illustration and decoration varies precisely in accordance with the immediacy of their contact with and inspiration from one of the major metropolitan arts of form. Even the Holbein borders based upon the Venetian designs, showing as they do the hand of a very great personality, nevertheless are provincial and somehow lacking in the authority that informed the work of the lesser man working in the direct shadow and tradition of the major art to which the fundamental designs go back.

The number of Venetian illustrated books was very large, and it is hardly worth while attempting to call your attention to any particular ones among them, as inevitably one would mention either too many or too few. Two of these picture-books, however, are of such great interest that they need to be spoken of in some little detail. The most important of them is the *Fascicolo de medicina* of Joannes Ketham that was published in 1493. It is not a fine book from the point of view of the typo-

graphic interior decorator, but it contains several large full-page pictures that, it seems to me, must be regarded as the most beautiful of all the woodcuts produced at Venice. It is quite out of the question to attempt to attribute them to any definite hand, for the carelessness of the woodcutter has deprived their lines of all the intimate characteristics of their designer, leaving only their big, free construction for us to see. This, however, much as it is to be regretted, does not in the least prevent us from recognizing in them the work of an artist to whom we are justified in applying the much overworked term "master." Whoever he was, this draftsman of the Ketham, he was far from being a minor person, and we may be sure that he was one of the good painters or sculptors of his day. These few designs of his represent almost the only occasion in early Italian book illustration upon which we may be certain that the illustrator was not a minor artist working in the shadow and tradition of a greater art. Here we can see a solidity, a certainty, and a bigness that overtop almost everything else that early book illustration has to show.

Lorenzo Giustiniano's *Della vita religiosa* of 1494 is another book that contains several fine cuts. These also are anonymous, and although they are not of very great importance, one of them is among the very few woodcuts of the time that can be immediately traced back, even at second hand, to the work of a major artist. The portrait of the author is quite definitely based upon the figure in the painting by Gentile Bellini in the Academy at Venice.

Mr. Pollard in his *Fine books*, after speaking of Venetian books that contain the larger cuts, says, "However good the large illustrations in Venetian books, the merits of them are rather those of single prints than of really appropriate book work." It is an attitude that has become very popular of late, thanks in large measure to Mr. Pollard's own very great authority and the lucidity and interest of his writing. But, again, one

must beg to differ, and in differing to ask the question, What would one think of a critic who should say that because the lines of a poem were of very unequal length, therefore they were not appropriate to be put in a book? Somehow it is no farther fetched than the other, and is precisely in accord with it in subordinating the merit of the contents of a book to the merits of the book as object seen two pages at a time. What Mr. Pollard has really said, in the sentence I have just quoted from him, is that book illustration is only good when it is artistically of minor rank and subordinate position. It is saying in almost so many words that no great artist can be a good illustrator, that no great works of art can be good illustrations. I admit that I appear before you as a print and picture man and not as a bookman, but I ask you, nevertheless, is there not something wrong with this conception? If followed up logically it would land us in the utterly foolish situation in which we should think that a book the text of which was altered from time to time so as to be appropriate to the interior-decorating fancies of the printer was a better book than one in which the text was written so as to be appropriate to what a great author had to say—and be damned to the printer! It is an attitude that could only possibly be exhibited as the result of an utterly artificial set of values, in which, to make an analogy, the shape of a musical instrument is of more importance than the sound it is capable of producing.

At Ferrara there were produced at least two books of importance and interest. The St. Jerome of 1497, fine as it is, contains nothing that is new, its well-designed cuts and borders being little more than able provincial echoes of the prevailing Venetian style. The Boccaccio *De mulieribus claris*, of the same year, is a memorable book, if for nothing else than the great amount of character that the artist and woodcutter succeeded in getting into a few of their small portraits of famous women. Its illustrations may be said to be the first collection of woodcut por-

traits of human beings as distinct from those of cigar-store Indians.

It is impossible to say just when "early books" ceased to be produced, the dead line of December 31, 1500, being no more than a purely conventional rule of comfort for librarians and cataloguers and having nothing whatever to do with actual fact. Both tradition and the time at my disposal make it fitting that I should not now discuss books produced after that day, but there is one thing that in all honesty I must call your attention to. It is the very important fact that the books which contain the most memorable pictures were, with exceedingly few exceptions, all printed after the close of 1500. It is doubtfully worth while going into the reasons for this, or the history of fine pictures in books, each being complex and in many ways obscure. There is no question, however, that in large measure it is due to the fact that until just before 1500 few woodcutters anywhere had achieved a degree of technical skill that enabled them to preserve anything of the idiosyncratic quality of a draftsman's lines. The earliest book in which a great artist's handwriting was definitely preserved was the Apocalypse that Dürer published at Nuremberg in 1498. After that came many more, and their number is still being added to. To say just in what beauty consists is impossible, but I doubt very much whether there are in existence very many illuminated manuscripts, with all their glory of blue and gold and red and green and purple, that for sheer artistry, power of draftsmanship, and great picture-making, are comparable to the series of printed books made memorable by the hands of such artists as Dürer and Holbein and Blake and Daumier and their fellows, for these men were not minor artists working in the shadows of the major artists of their day, as were practically all the miniaturists, but were themselves among the greatest of their times. Their books stand with the books that contain the earliest editions of the great texts, on the side of the spirit and not on that of luxurious

furniture. In one respect they are even more important or interesting than the great first editions of texts—that whereas the text remains the same, given careful proofreading, no matter when or how printed, and in many cases is capable of yielding its best to the reader only in some cheapest and handiest and most unassuming of reprints, the great picture-books only yield their utmost of understanding and meaning when used in the earliest and finest impressions. From the point of view of literary enjoyment of a text, the cheap reprint is the best thing there is, the first edition being merely a matter of sentiment and of pedantry. From the point of view of artistic enjoyment of a printed picture, few reprints and no reproductions are other than libels upon their glorious originals.

Early books are so well known and have been so minutely and lovingly studied for so long a period that there is very little that remains to be said about them. Their study has progressed so far that it may be said with approximate truth to have reached a point where it now constitutes an independent branch of knowledge or science quite cut off from many other things that at first sight—and if I may be allowed to say so, in final analysis as well—have much to do with them. It is time, in a way, that they should be brought back into their true relationship to certain aspects and valuations that are of great importance. Very few things in this world are of importance except by virtue of their relationship to other things, and old books, no more than any other things, are exempt from this general rule. As artifacts old books are capable of containing or exhibiting much beauty, but this beauty is of a nature that for validity needs to be checked and controlled by reference to other objects. It happens that a very small portion of the people who busy themselves with old books and who have been responsible for the valuations that are put upon them have been in any notable measure conversant with other things such as architecture, sculpture, or pictures—and this aloofness of theirs has had re-

sults that cannot be ignored except at the cost of certain fundamental misapprehensions or misunderstandings. A man spends his life in a library hump-shouldered over old books and fails to realize that while he learns much about books, his very concentration upon them makes it impossible for him to have at least that nodding acquaintance with other things without which he is incapable of forming any reasonable set of opinions and values about his books. In these days it is the fashion to allow experts to set our values for us, and the evil results of this are visible all through our modern life. If it could be realized that an expert has only become expert by forfeiting any comparative and therefore true sense of values, we should once more get back to the reign of enlightened amateurism, for in the event it is only the amateur, who has played at many games, not necessarily playing any of them exceedingly well, but able to have some ideas about their comparative values, who is able to form reasonable judgments about them. Until books are brought into line with the other things that men have made, I think I am justified in saying that we can really know nothing about them that is of much importance, and neither can we have any true sense of their values. Having ceased to read the texts of early books, we can still look at them for the remaining things they contain of substantive as distinct from adjectival importance, the pictures that are contained in them, and these we cannot understand or know much of until we look at them as we look at other pictures, in conjunction with the architecture and sculpture and other pictures of their time. No text both written and printed in the second half of the fifteenth century begins to have the continuing interest or importance for living men that many a series of fifteenth-century illustrations has, even it may be doubted if all of them together are as important to us as cultured men and women as that one set of designs for the Apocalypse that Dürer published in 1498. As long as we study

their pictures as mere adjuncts, things subsidiary to typography, we shall fail to appreciate that the surviving claims of early books upon the serious attention of cultured men and women lie precisely in their pictures, as the place where these books for us come in closest touch with the great and living traditions of human culture.

GLEANINGS FROM INCUNABULA OF SCIENCE AND MEDICINE

By Arnold C. Klebs

IN MODERN times the name of "science" is applied to manifold human activities. This indicates that the process of specialistic grouping of efforts still continues and that the application of the successful methods of natural science within such groups holds out the greatest promise of progress. Sometimes we resent the intrusion of newcomers in fields which we have long tilled with care and have come to regard as a privileged possession. To allow, however, the title of "science" only to disinterested pursuits of knowledge by certain approved methods and without reference to any practical application would be a futile and unpopular gesture. We are certainly still far from an ideal science which, inspired by Terence's famous words, "homo sum, humani nihil a me alienum puto," would embrace the whole range of all that is knowable and at the same time beneficial to mankind. We have accumulated and stored so much that we are simply forced to specialize.[1] Despite the fact, often pointed out, that in the evolution of living beings, plants and animals, extreme specialization stops progress, that only the generalized types produce higher forms, and that in human history in Alexandria and Rome the same took place, we see nevertheless no way by which the modern tendency can be stopped, and we are even convinced that only by specialistic research can really notable advances be made.

Medicine occupies a unique and persistent position in all these canalizing activities. Somehow its function escapes every attempt at a sharp delimitation and definition. It is character-

istic that Sarton in his admirable *Introduction* finds it easy to indicate for every branch of science which he enumerates its object and scope, except for medicine, which he leaves undefined.[2] But perhaps by saying "medical sciences" and not "medicine" he thought he had given all necessary definition, leaving the details to the text of his third series, for which he gives only the outline here. When he reaches this stage of his work he will doubtless have become aware of the fact that the principal actors in the human drama he unfolds before us are almost all physicians. There were three professions, it must be admitted, that clamored for the honor of having been the original specialties, that of the priest, of the magician, and of the physician. They all professed in common to possess special knowledge with which they could help their fellow-beings and their tribe. We need not examine here why and how they did it; we shall only note that in every primitive society of man, one or more of these craftsmen had segregated themselves from the common herd in order to minister to obvious needs. All three have come down to us, borrowing from one another, proud of their knowledge and their calling, except the magician, who has to use various disguises, for he is much misunderstood these days.

No doubt, therefore, the physician—we shall not consider the other two just now—was an early if not the earliest man of science. But merely to profess his knowledge was not enough, for he had to show how he could provide for definite needs of his tribe. Strongly desirous to help, feeling in himself the power that he could help, he went to acquire knowledge. And in this ardent striving he scanned the skies and trod the earth searching for remedies, above and below, to alleviate suffering. The knowledge he acquired he registered and passed on with guiding words to his son, and he to his son, and so on. And here he still is and he can boast, as Osler said, of the same unbroken continuity of methods and ideals.[3] He is still the craftsman of old, but he has learned much, and his skill has become greater;

he has taken from the sciences that sprang from his craft all they could give him for his needs; some of them he has built and adapted to these needs. With his hand on the pulse of suffering man, his eyes fixed on the hidden sores and miseries of civilization, his ears open to the plaints of sick and shattered existences, he found he needed so much more than these sciences could provide. He even found that sometimes they tempted him away from his principal task to glorious adventures in promising bypaths of search and circumscribed effort. He tried these narrow paths but never lost the broader outlook. Did not Dante, that divine bard of all human aspirations, ask for admittance at the door of the physicians' guild in Florence, and with him and after him all the wisest and best thinkers of the times, and the great painters? So today do they need a better label than that of medicine? Rightly a national homage was paid to one of their leaders, and the president of this republic said before him, "Dr. Welch is our greatest statesman in the field of public health." Yes, public health, a great ideal and a wide field; the maintenance of that vigor and well-being without which nothing is possible; in comparison with it what is that science that provides salable mechanical gadgets, elaborate classifications and formulas of so-called positive knowledge, unless constructive and sympathetic thought is given to the wider problems of mankind? It is notable that Dr. Welch should now head an entirely new institution which, by the study of history, attempts, and no doubt will succeed, to integrate the multiple specialties into which modern medicine has become divided.

Scientific Thought and Action

The simple experience which teaches us that the effectiveness of a bodily action is proportionally increased by its repetition so that it becomes a habit, a more or less unconscious automatism, is at the bottom of all successful craftsmanship. It establishes a rule that holds good for both the "skilled" and "learned"

crafts. Whether or not these aptitudes of body and mind are inheritable is still a moot question, but historically the fact seems corroborated that crafts run in families. One thing seems clear, and that is that in their evolution they do not run parallel courses. The more delicate and complex a technical action becomes in the naturally restrained field, the more should one expect the mind to expand to ever wider fields of new activities. But this is not so, and one observes almost invariably that the action habit also entails a thought habit that forces the mind into the field of action from which it can extricate itself only in the rare cases of great intellectual elasticity. The technical evolution has outrun somatic evolution. The effect on materialistic science is inevitable. Our instrumental facilities as to accuracy have been enormously perfected, so that everything of former ages seems incredibly crude to us; and still there are no indications that our mental powers, of discernment, of judgment, have correspondingly grown. Nay, we find sometimes among the older authors infinitely simpler, saner approaches to and judgments of problems for which sometimes fantastic solutions are proposed by modern experimentalists. A time seems to have come when it would appear to be profitable to slow up the rhythm of instrumental and experimental subtilization, and turn to the problems imposed by the broader human needs and not merely by a successful methodology.

The Printing Machine

A striving for machine-like precision underlies most modern scientific and medical aspirations. It is well to recognize this and to realize its advantages and shortcomings. As in a real machine, the mechanization of thought increases the scope and effectiveness of action, but only inside of restrained fields. A modern machine is a complex affair, an assembly of machines. Improvement of component parts can increase its efficiency up to a certain extent, but a time comes when this does not pay

any more and the machine has to be scrapped and a new one built. Human thought inhibited by tradition and age-old habits resists, even when mechanized, this scrapping and rebuilding. It makes its improvements inside of the old structure. We express this when we say that the machine is getting the better of us, and we try to improve the machine by making it foolproof, to simplify its operation. This interplay and mutual adaptation of the mental and the material machine dominate all modern scientific striving, and if we look through the annals of history for the origin of this evolutionary element, we are forced to find it at that moment when the machine enters the realm of thought, that is, when the printing press made the results of individual intellectual and technical labor utilizable by an ever increasing number of pupils. Thus for the turn that science has taken, the advent of the printed book is of fundamental importance; modern scientific progress is simply unthinkable, impossible, without it. In the approach to an ultimate science based on ideal truth we have deliberately chosen the machine as our helpmate. It has given us excellent service in the limited field of material experience and we have good hopes of gradually transcending the self-imposed boundaries by a better understanding of the interplay of matter and energy, and its effect on wider human aspiration. There is much work for laboratories still ahead, and they will have to widen their scope so as to embrace also that practically untapped field of research, human thought itself, in recognition of the fact that thought of all ages is equivalent, deserving scientific consideration like any other fact of nature. We have learned to preserve an objective and dignified attitude when we are facing nature. We no more speak of her whims and fancies; we simply approach them unmoved. But when facing thought we become uneasy and emotional; what does not fit into the thought habits acquired in a bad school we call all sorts of names: superstitious, credulous, infantile, etc. We are indignant and arrogant

when we find somebody attacking our favorite ideas, especially all the "-isms" from Darwinism to behaviorism. If we want to preserve our scientific self-respect we have to relearn many things, and especially attain a dignified respect for the thoughts of others and especially for the thought of earlier workers who, while lacking some of our advantages, had none of our prejudices. We have the most unscientific conviction that we are the end and the top of evolution, when we ought to know that our age is but a phase in a long process and that five hundred years from now our work and thought will be judged as we judge now the work and thought of the men who for the first time printed it on paper so as to exchange it with others. And as water is always clearest at its source, any study of modern scientific thought can suitably begin with that of the incunabula literature, which, as I shall try to show, links the thoughts not of one but of a hundred ages.

Incunabula

It is not necessary here to discuss the many points of interest which the incunabula have for the bibliographer, the archaeologist, and the collector. In the past twenty years this interest has grown to a remarkable extent, and justly so, for it would be difficult to find another object of antiquarian interest which marks so sharply and so precisely a decided turn in human affairs. It is natural that incunabula have mainly been studied as the artistic products of the first printers rather than as to their contents. There was so much to do in the clearing of the often obscure origin of unsigned incunabula, in the following-up of the complex wanderings of some printers, in the studying of their types and their practices of composition. This part of the work goes on persistently though slowly. The exact description and determination of some forty thousand single items, some of them extant only in unique copies and often

widely separated in different corners of the world, is a very difficult undertaking, especially since there are comparatively few workers in the field who have reached the necessary degree of competence for making descriptions and determinations. Nevertheless, the accumulation of reliable material has augmented to such an extent that the analysis of the contents of these books, and with that the dissemination of ideas during the period under consideration, can now be undertaken with a fair promise of profit. Why this has not been done before explains itself, not only because of the inaccessibility and insufficient preparation of the material, but also because of a bias in favor of manuscripts as offering better source material for literary studies than the incunabula or early printed books. It is perhaps incorrect to speak of a bias, because the student of the manuscript literature as a rule leaves the printed material *ipso facto* out of consideration, and takes a special interest in those manuscripts which were not printed at all. The objection to incunabula because they reproduce badly the manuscript texts, or because they are based on inferior texts, is occasionally heard, but is rarely based on a systematic examination and comparison of various editions.

I have given to the study of incunabula of medicine and science the better part of the past fifteen years after having been introduced to them in the Surgeon General's Library by Colonel Fielding H. Garrison. I am now engaged with the final revision of a general bibliography of the incunabula of science and medicine, a work which, with the welcome assistance of the New York Academy of Medicine, I hope to bring to an early termination. I have extracted from my records data which I believe can throw a clearer light than hitherto obtainable, on the extent, on the various aspects, and on the paths of dissemination of the earliest scientific literature as it issued from the first European presses.

The Printers

We know very little about the individual lives of the earliest printers. For information we have to depend mostly on inferences we can draw from their work. These suggest that they were by no means only journeymen or specialized craftsmen, such as they were soon to become, but often academically trained men with a good knowledge of the works they were handling and printing, guided by the advice and help of the learned with whom they naturally associated. As the promoters of a new art they were probably less mechanized and specialized than, for instance, the professional scriveners.[5] They were the true descendants of the *vagantes*, the wandering scholars of the early Middle Ages, unknown, poor, but cheerful carriers of progressive, because living, thought.[6] When the early printer rises out of the usual anonymity by attaining material prosperity we get to know him better. Most often he becomes a powerful head of a great press in continuous contact with the intellectual work of the day like Schöffer at Mainz and Koberger at Nuremberg, some creating around their press a little academy of their own like Aldus Manutius at Venice, others mainly shrewd business men like Vérard in Paris, and only a very few like Müller Regiomontanus, who uses his press for his scientific work just as today we would use the typewriter.

Of the channels by which manuscripts, as "copy," reached the earliest presses we have no comprehensive account; we learn about them only by casual references in the books themselves, to patrons, correctors, and others associated in the publishing work, also from accounts, contracts, and correspondence of printers in often rather inaccessible documents. The printers evidently were too busy doing things, the others too busy furnishing copy; nobody had time to talk about it, less to write of it. It is characteristic of this intense preoccupation that we have no single incunable in which the method of printing is explained. But from documentary and other evidence we can

infer that with certain rather typical exceptions, the scientific men of the day took a very active interest in the promotion of printing. I have elsewhere gone into this evidence in detail.[7] It seems to show that especially medical men furthered with great energy and sacrifices the new art. Those who did not share the interest in the new art were the ones, occurring in every age, who on general principles object to innovation.

The reaction against the printing machine was an ephemeral one, but it is interesting to fix our attention on it, because it illustrates already at that time the deep-seated antipathy against all mechanical, machine-like performance. Man is an animal distinguished from others by his ability to make and use tools so as to free himself in order to master his surroundings, but when once his tool, by his efforts, has reached a certain degree of complexity, he begins to fear it; he longs for and perhaps attains simplicity once more, to begin over again. It is the same in the intellectual as in the mechanical realm. The Greeks began building with their philosophical tools the Alexandrian machine, the Christian thinkers with Arab and other helpers in similar striving produced the scholastic machine, and parallel with them out of medieval craftsmanship came the printing machine. And the humanists who heralded the new freedom patterned on Greek models in that movement which *they* called Renaissance turned against both scholasticism and printing, little aware that they themselves were playing a part in the scientific evolution which inevitably would lead again to greater complexity, to the huge machine which *we* call "modern science." It was not against the essence of scholasticism that the man of the Renaissance turned, for that was based on the very Greek ideals which he thought to have rediscovered; he merely turned against its complexity and machine-like precision. In his rather artificial, pagan joyousness and motility, he felt hemmed in by the tyranny of the syllogism and bored by too finely spun subtleties; the sonorous rhythm of Ciceronian dia-

lectics and Virgilian lyrics suited him better. Also could he see nothing of the deep feeling and spiritual elevation in medieval sculpture or painting or building; all seemed futile and rather mechanical symbolisms vastly surpassed by the beautiful realism of the art of Phidias and Praxiteles. We cannot help but see in this Renaissance, just as in the Reformation, that grew out of it, a revolutionary movement which ruffles the surface but does not touch the deeper substance of the stream of human destiny. The machine had come into the world, and it had come to stay.

If formal rather than substantial, our debt to the Renaissance is nevertheless great. Undoubtedly it has improved language, not only Latin but the vulgar tongues equally. Many of the better texts that came under the new presses we owe to the labor of the humanists. Ruskin exaggerates when he rages against the soullessness of Renaissance architecture, but there is much truth in his contention that only great genius in art can proceed by means of mathematical and scientific preciseness to harmonious creation. Beautiful work was done by the painters, and the scientific book owes much to the surer and truer delineation of the artist and the fine craftsmanship of the woodcutter. By blending the simple forms of the Carolingian minuscule with those of the sober Roman majuscules the humanistic penman gave us the script we still use, but which had reached the acme of its perfection in the types of Jenson's Venetian press and some of its successful imitators. It was expressive of the reaction against the complexity of the monastic script which the Italian classicists had dubbed "Gothic," viz., "barbaric," in their unreasoning contempt for all that had come to them from that age. They thought it an intruder between antiquity and themselves and so coined the derogatory epithet "Middle Ages." But curiously, the Gothic script held out for long in printing, against the Roman, especially in scientific literature. Of its forms the majestic *textura*, created by Gùten-

berg's craftsmanship for his Bible, prevailed as "black letter" in many Dutch, English, and other presses; the *lettera veneta*, a fine Gothic *rotunda*, improved by Jenson, had a wide sway in all Europe; the lively "bastard" forms held the vogue in France, and as *Schwabacher* or *Fractura* still compete with the Roman in Germanic lands. It is an earmark of confidence in "scholasticism," which to the humanists spelled futile speculation and pedantry; but to others confidence in solid, disciplined thought, confidence in that thought which had found its highest expression in an all-embracing synthesis of knowing faith, in the *Summa* of a Thomas Aquinas.[8] Like the Gothic cathedral, a harmonious creation of many thoughtful minds and skilful hands, it stood there in glorious grandeur, holding out to suffering mankind the promises of salvation.

Now, as little as then, have we any accurate means of ascertaining what kind of literature and which books were most read and so exerted a determinable cultural influence. For incunabula we cannot even calculate, as we can for books today, which were the best sellers. We can, however, say with fair accuracy which authors and which books were most frequently reprinted. (Here we are ahead of today, when the first edition can appear simultaneously with, say, the two-hundredth.) The determination is of great interest even if we do not know, or at least rarely know, the exact number of copies per edition (varying from three hundred to three thousand). We can also estimate further, by the number of editions, the relative degree of interest in definite subjects. Of course in such comparison the fact must always be taken into consideration that a broadsheet or a small pamphlet can more easily be reprinted than a large volume, but naturally the greatest difficulty is experienced when one tries to classify the various books according to subjects. To take our classification of the modern sciences as the basis of such a subject list would necessitate a violent disturbance of the intellectual atmosphere of the time we wish to study.

For it is necessary to remember always that even when we are able to separate certain disciplines from the broad subject of science as then understood, this separate subject never stands by itself in the sense of a modern specialty; the author's mind will invariably oscillate between his subject and others and consider applications which we would strictly avoid. Hence a certain amount of arbitrariness has to prevail in the selection of subjects, and in general it may be said that the ideal of perfect consistency can never be reached in this matter.[9]

Authors

Rows of names head as authors our incunabula. They hail from many countries, and from every age, from Hippocrates to Sebastian Brant. Evidently they must have inspired confidence in their worth in those that selected them for the press. Some proved to be "successes" and were passed on as such to the next century. Others could not stand the strong light of the new publicity; though popular enough in script, they looked old and decrepit on the printed page. Soon they were dropped, to fall into oblivion. Thus we have in incunabula an admirably accurate barometer with which to gauge the pressure of scientific thought. But whence came the pressure? Who were the authors? The quattrocento humanists (those of the twelfth were not so cocksure) thought they lacked freedom and originality. Faithfully this was repeated by the later ages, copying each other. But Taylor, to whom we do well to listen on everything touching the Middle Ages, thinks differently:

> From the Carolingian period onward the men interested in knowledge learned the patristic theology, and, in gradually expanding compass, acquired antique logic and metaphysics, mathematics, natural science and jurisprudence. . . . . Their comprehension of it became part of their intellectual faculties, they could think for themselves in its terms, think almost originally and creatively, and could present as their own the matter of their thoughts in restatements, that is in forms, essentially new.[10]

The originality, the novelty, in this creative realization, therefore, was in the form and not in the substance; in concepts, in words, not things. Who does better? We think we have something more tangible, fascinated as we are by the seemingly unlimited range of power we can extract from our instruments or effect by our machines. Is this "substantial" contribution so original? Have we not also only changed one form into another form when we successfully attacked matter? By what magic should the material field convey upon its fruit a light of originality of which the mental field is barren? In substance man worked only once originally, and that was when he made a fire. That was the great outstanding deed in all his evolution. And this elementary creation made that upper organ, his brain, with which he could make concepts, words, and handle them like things. But they were words only, convenient approaches to a few "facts" in an immense universe, and with them he was enabled to make all those mental, but also those material, constructions that fascinate us now. No, we have not invented a "new" originality, which those "authors" lacked. Better, perhaps, should we speak of both in the etymological sense of "augmenters."

The Earliest "Authors"

The history which follows the prejudiced Renaissance tradition usually places Pliny, Galen, and Ptolemy in the forefront as the scientific teachers of a benighted humanity. In the incunabula period we have them of course in full force. But in that earliest age which we call "dark" because the records are so scant, when in the monastery schools the fires of learning were kept burning, in wild regions of what is now Italy, Spain, France, Germany, Switzerland, Ireland, England, they had not yet arrived. Priscian provided the juvenile terror, Ovid and Virgil the adult joy, of language. Diligent monks had copied them in portable compendia, and soon they were known by heart. With

them came similarly Boethius, Cassiodorus, and Martianus Capella. They were the three pillars of the bridge that carried antique learning through troubled times. Their names still vibrate inspiringly in incunabula times, Boethius' immortal work being called for in numerous editions in Latin and the vulgar tongues. Martianus Capella, the African, in his immensely popular work introduced generations to the charms of the seven liberal arts, which he figured as bridesmaids at the wedding of Philology and Mercury. And Cassiodor the senator, Boethius' young admirer and with him in high places under Theodorich, did effective spadework, also for scientific culture, in his monastery the Vivarium in Calabria, even more than his famous contemporary, St. Benedict of Nursia, at Monte Cassino, by stimulating his monks to literary occupation, to the copying and extracting of authors on natural science which he named and showed in the library. His and Martianus' work had been programmatical and encyclopedic; it inspired and guided the studies of the monastic and cathedral schools, and in Carolingian times it was fully adopted. Boethius' contribution was of different stuff and scope. Few books had a wider and deeper popularity than his *Consolation of philosophy*. The form of dialogue, intermixed with verse, made a great appeal. Not a scientific book, it made innumerable proselytes for science. As a cosmogony in great style it offered inspiration to a Dante. But he also wrote as a teacher of scientific subjects. Important is his mathematical work derived from Nicomachus. But fundamental for all times to come was his translation of Aristotle's *Logics*. Long before "the philosopher" was to appear again in Arabic garb to a more sophisticated people, his rules of disciplined thought were learned and applied over and over again. Already the crucial questions put by Porphyry in his *Isagoge to the logics* were revolved and considered: "Genera and species, have they substantial existence or are they bare intellectual concepts; if substantial are they corporeal or incorporeal; are

they separable from sensible properties of the things?" "These questions," he concluded, "require a longer investigation." Realists and nominalists carried it on for centuries, and if we listen to our physicists today we realize that they are still occupied with the investigation of this problem. Posited as it was, its scientific importance consists in that it stimulated powerfully, and from these earliest times steadily on, the gathering of data that might help in its solution.

"Popular" Science

There is another literature to be considered that held its own from very early medieval times to the incunabula period and beyond. It reproduces thoughts and strivings of this childhood phase of European culture which I think just for this reason merits closest attention, for we have learned to realize the powerful effect which early memories and early habits have on later destiny. It is mostly anonymous or pseudonymous, mainly didactic, and sometimes in metric form and therefore often classed as "pseudo-science" or "popular science," and variously evaluated. Thus Manitius[11] states that medieval man, lacking the sense for exact observation necessary for natural science and philosophy, was little helped by the Roman *compendia* he had, as they were only "dilettante and superstitious writings." To the average clerk, he thinks, mathematics and the science dependent on it were a closed book, the *computus* and *compendia* on theoretical music answering merely practical needs. Olschki discusses the same point in connection with somewhat later books, and especially those in the vulgar tongues.[12] He distinguishes two classes of these books, the ones intended purely for edification such as the French *Roman de la rose* or the *Divina commedia*, and schoolbooks such as Brunetto Latini's *Trésor*, Ristoro d'Arezzo's *Composizione del mondo*, Megenberg's *Buch der Natur*. According to him the former class, though dwelling on natural and realistic phenomena, has no influence whatever

(or a bad one, leading to a magical or pseudo-scientific attitude) on scientific evolution, while the latter serve as a useful introduction. In this view he turns decidedly against that of Alexander von Humboldt, who insisted on the useful interplay of "serious knowledge and the delicate inspiration of fantasy" in advancing culture. A feeling for nature, poetical description of natural events, landscape painting, he thought, were means of stimulating the more serious search. I sympathize with this "romantic" view, though I am well aware that the emotional contemplation of nature will more easily lead to artistic creation than to logical and critical analysis, but then again we cannot possibly think of an epoch as scientifically sterile in which a *Roman de la rose* or a *Divine comedy* could have been written. They might have led, or as some have it misled, the general intellectual evolution into other fields than those of exact scientific thought (as has happened in most oriental civilizations), but the point that matters is that they mark vividly the existence of a decided interest in the objects of natural science. History cannot afford to ignore the fact of this interest.

Regimen of Health

Man's prime interest is in himself and his likes. Hence it would follow that when he gives expression of this interest in the tangible domain it will occupy itself with the welfare of his body, with his health. Even if for some reason or other he reverts to intangible domains, the interest in the body still prevails though it becomes negative and is expressed in asceticism and self-castigation. So whichever way he turns, he will formulate a *regimen sanitatis*. Earthbound and carnally minded, it will assume an orderly procedure, scientific in our sense, because naturally striving for accuracy. *Fons* and *origo* of all science and all the sciences, the literary expressions of this egotistical tendency merit always attention. In the incunable literature we find two *regimina sanitatis*, enormously popular then and

for centuries after. Their age has not yet been satisfactorily determined. One is in prose in the form of an admonitory letter from Aristotle to his young pupil Alexander, not only on health but also on rules appropriate for a budding prince; the other, in verses, purports to be the joint expression of the famous School of Salerno. The Aristotle letter is, according to Sudhoff, the older of the two. He found traces of it in Sicily and Toledo already in the twelfth century, while there are no definite traces of the Salernitan *opus* much before Arnaldus de Villanova wrote his commentary to it at the end of the thirteenth or beginning of the fourteenth century; Sudhoff does not even exclude the possibility of Arnaldus having written the verses himself. There can be no question about the relative popularity of the two works, the second being one of the most frequently reissued books in the world, while the Aristotle letter survived mainly because it found a German translator in the fifteenth century who procured for it great local favor.[13]

The Salernitan poem as it has come down to us contains numerous interpolations and additions. Such were made probably from its beginning, and one can only guess that those dealing with diet were the original verses. No author is named in it, but its Salernitan origin cannot well be doubted, neither the authenticity of its dedication to a king of England, probably William II, whose brother Robert, Duke of Normandy, underwent treatment at Salerno on his return from a crusade in 1099. We have no clear record about a co-operative medical activity in Salerno until the middle of the eleventh century, that is, at least a generation before the advent of Constantine the African and the first European universities of Bologna and Paris. But we have many reasons that allow us to suspect that there was one for many generations before this date, and there is internal evidence in the *Regimen* which makes one feel that its origins fall into this older period. As Daremberg has well said:

It is the work of everybody, and it is the work of nobody; or rather it is the true echo of the good sense of a people in matters of hygiene; it has all the characteristics of a popular writing; the precision, a certain naïveté, happy turns of expression, and I don't know what, something living and what one would not expect to find in a school poem.[14]

Salerno, it must not be forgotten, was a great health resort in Roman imperial times. It also belonged to Magna Graecia, whose language and customs survived for long under Byzantine, Lombard, Norman, Sawbian, and Moslem rule. The earliest masters of the school testify to the vitality of the Graeco-Latin tradition, before the arrival of Constantine the African and his Greek and Latin science from Arabic sources, and before Frederick II regularized the study and practice of medicine—all of which meant the end of that tradition, though in some ways the fame of the school was spread more than before.

It is a slender thread, this *Regimen*, with which to tie the bulky structure of the future science to a dim past. There were others, of course, spun in Roman and Visigothic Spain, in Egypt, Syria, and the Byzantine Empire, but the subtle, pervasive, and persistent influence of the *Regimen* and the literature directly related to it in many ways illustrates better the continuous flux of events than the highlights reached at intervals. The knowledge of healing herbs was naturally embodied in the *Regimen*. It also was a very ancient science, this of rhizotomists that furnished material for a Theophrastos and Dioscorides. Many of the verses on this in the *Regimen* are also found in the famous *Macer floridus*, *de viribus herbarum*. Therefore, it was thought, they must have been taken from this earlier poem. But who knows that it was earlier? The name of the author points to Aemilius, of whose herb lore we read in Ovid's *Tristia*, but philologists will allow no resemblance to his authentic works. Imperial Rome knew nothing of it, just as little as of the *Herbarium* and the *De re coquinaria*, sailing respectively under the classic names of Apuleius and Apicius until they reached the

port of incunable presses. I have no proofs, only little indications here and there that make me feel that all this pseudonymous literature on diet, hygiene, food, and herbs are echoes of Salernitan or pre-Salernitan activities. We also have the old *Physiologus*, perhaps scientifically unimportant, because allegorically versifying animal lore. It points to Monte Cassino, where Theobaldus, its presumed author, once was abbot. Then we have the poem on the virtues of Pozzuoli's mineral springs; Puteoli, that later rival of Salerno, close to Naples where Frederick II had transferred the university, artificially, and none too successfully. Early traces of an occupation with astronomical subjects as we find them in the fables of Hyginus, in Solinus, the abbreviated *Quadripartitum* of Ptolemy in the form of the popular *Centiloquium* make us think of a beginning of pure science, but then already and for times to come the interest was astrological, that is, again in relation to human health and welfare and the art of divination.

Illustration

Curious is the fate of the *Herbarium Apulei*, referred to above. We have some ancient manuscripts of it, mostly with plant pictures, some of which Singer has finely reproduced.[15] One of the best dates from the early seventh century and is now at Leyden, and an Anglo-Saxon version of it was made already in the eleventh century. Its origin is earlier, however, though not as early as the time of Lucius Apuleius of Madaura, who wrote the *Golden ass*. Renowned as a great magician throughout the Middle Ages from the third century on, his name was probably appended to this book in memory of his scientific powers. It is merely a list of medicinal plants, giving briefly indications of their virtues and synonyms of their names with corresponding though rather crude pictures. It represents a purely practical abridgment of the more elaborate and more realistic herbals of Byzantine craftsmanship, of which a very fine speci-

men, the Dioscorides Codex, dedicated to the Emperor's daughter, Juliana Anicia, is still extant. The Apuleius herbal, copied and recopied through centuries, testifies to a remarkable continuity of tradition, and undoubtedly fulfilled an expressed demand for this sort of book. When the first presses began printing in Rome, the owner of one, Lignamine, finding one of these manuscripts in Monte Cassino, decided to print it. It appeared about 1480 with illustrations, but never again in that form. Nevertheless in 1484 it was re-formed by the famous press of Schöffer in Mainz as the *Herbarius*. Not a copy by any means, only the adoption of the principle of the herbal with more realistic pictures, and as such it became the starting-point of a long line of herbals, continually improving in precision of text and illustration, through the famous works of the "fathers of botany" in the sixteenth century, to our "truly" scientific textbooks of botany. The printing press did in one century what the thousand years before could not possibly have done.[16]

With the beginning of the great schools of translators in Southern Italy, where Constantine the African is the most prominent representative, and in Spain, where Gerard of Cremona holds a similar place, the Latin scientific literature becomes at once abundant and complex. While Europe was struggling with elementary difficulties of existence, Moslem civilization had already reached a high degree of material prosperity and devoted itself to manifold cultural aims. Most important among these was the preservation of the scientific literature which had been gathered from Alexandrian Greek as well as from Persian and Indian sources. Arabic was the scientific language of that movement, and it is yet one of the tasks for the history of science, to discern how much Arabic science has contributed of her own to the bulk taken over from other sources. That the contribution was readily absorbed by a Europe thirsting for knowledge, and well prepared for it in those centuries following the dissolution of the imperial power of Rome, is evi-

dent in a massive manuscript literature of which the most popular representatives came under the early presses. In the space at my disposal it would be impossible to give anything approaching an adequate outline of this literature, and I shall therefore limit myself to describing what were the most popular books printed at the end of the fifteenth century, feeling that whatever our present judgment might be of the worth of these books, they fulfilled without doubt their mission in those days.

ALBERTUS MAGNUS: *Liber aggregationis. De mirabilibus mundi*

The erudite of many lands and tempers have called this little book by bad names, and have considered it an insult to the lofty scientific reputation of the Great Albert, who, they say, could not possibly have written it. I know only one, an American, who kept his temper and showed his sense of humor when he refused to listen to all these learned vituperations of a book which he found in innumerable manuscript and printed editions and which therefore must have made a decided appeal to the reading public through many centuries. For him as a scientific observer of past thought there was only one thing to do, to analyze the contents. This American, L. Thorndike, I shall follow in the not always easy task of scrutinizing this kind of scientific literature.[17] In the incunable editions, of which we count from about 1477 on more than sixty, the book is called mostly by the foregoing title, or *Book of secrets*, or *Of the virtues of herbs, stones and animals*. In the manuscripts it is often entitled *Experimenta*. The treatise on *The wonders of the worlds* is sometimes added to the *Aggregator*. Both these works profess a belief in magic and in wonders, just as Albert does in his so-called genuine works, so that this element, which enrages most the erudite critics, cannot speak against this authorship. In the *mirabilia* he states clearly: "It is the wise man's business to make an end of marvels" and "a thing is marvelous and wonderful (pet expressions of our advanced civilization) only as long as most people cannot detect its cause . . . . when philosophers

realized that everything was wonderful, they began to experiment and bring forth what there was in things." The only reproach that can be made to the author is that he is too satisfied to reveal the sensational features of the various wonderful virtues of things and marvelous occurrences in nature without a more serious attempt to explain them. Evidently the experimental school of the Dominicans in Cologne, which the author mentions and with which we know Albert to have been connected, had not yet been able to find adequate solutions. Notable is a critical attitude toward contemporary attempts to explain everything in terms of the hot, cold, dry, moist, following Galen, also against similar explanations from the course of the stars, but of course "one must be prepared to believe what reason cannot confirm." Some of the chemical recipes for making gunpowder, fireworks, etc., are interesting if they date from the thirteenth century, but they may be later interpolations.

The next book in the order of popularity is also attributed to the same author, with more than fifty incunable editions:

ALBERTUS MAGNUS: *Secreta mulierum*

This again, some say, cannot be by Albert the Great; it probably is by his pupil, Henry of Saxony, or by an Albert of Saxony —all unhelpful conjectures, owing to a too serious consideration of the whims and fancies of scribes and printers who liked to increase the interest in their products by altering the headlines. Again here, as with the *Aggregator*, we can only say that the views expressed on processes of generation, birth and care of infants, are not incompatible with similar views expressed in Albert's admittedly genuine works. It was put on the Index because of its alleged obscenity, and therefore had to be handled like other products of prohibition with circumspection, with the natural result that its popularity was increased. In the history of obstetrical thought and practice the little book has an entirely honorable place.

A great part of Albert's scientific as well as theological con-

tributions were printed by the incunable presses. We have a dozen or more titles of scientific interest. His immense literary activity consisted mainly in paraphrasing the work of Aristotle, from Latin translations of Arabic versions, and in close contact with the work of Avicenna. A full estimation of his addition to the traditional knowledge becomes possible only through advancing research, but already we can fathom that it was very considerable.

AVICENNA: *Canon medicinae*

That after five hundred years the name of the great Persian physician and his system of medical theory and practice should have maintained their incredible popularity, and that it should have continued for at least another hundred years, are sufficient reasons to regard the book as one of the most significant intellectual phenomena of all times. In the Arab world of today he is still as he was then, the "prince of philosophers." To the modern scientific physician who tends more and more to retire from active practice into the quiet of pure laboratory research, Avicenna should make a special appeal, for he held that it was infinitely more important for a physician to know one hundred books than to see a single patient. In an immense range of subjects which engaged his inquiring scientific mind, medicine seemed rather simple. But this simplicity must have seemed rather complex to the poor student who had to work his way through the bulky and ponderous volumes. Rigid order with a clear classification after a definite system being then, as now, the basis of a scientific textbook, Avicenna's *Canon* answered admirably to the demands for a comprehensive guide to clinical teaching. Being difficult to understand in part, intrinsically and also because of blundering renderings of Arabic terms in barbaric jargon by careless translators, many men thought it necessary to expound and elucidate the words of the master. Thus the commentation of Avicenna provided material for spe-

cial-research students. So it comes that the canonic literature of medicine called for a great number of editions. We do not know the exact proportion of Avicenna's original additions to the evident borrowings from Greek sources. His theories, and the classification of phenomena based thereupon, naturally differ from ours, but the careful reader, even today, can find—often hidden, alas, in what seems to us useless verbiage—very shrewd observations of a scientifically trained man of the world, clear descriptions of rare diseases, and some conceptions about the etiology of disease which have a curiously modern flavor. Avicenna is not the first but the last of the many great Persian and Arabic systematizers of medicine, but the comprehensiveness of the *Canon* gave it unique distinction as a schoolbook for long generations.

The next of incunabula "best sellers" which I now have to present in the order of popular evaluation offers again some of those features that send shivers down the backs of the really erudite historian.

Lucidarius

Among the starving intellects there were some that asked: "How is this big world divided? What are those islands peopled with Indians? What those strange folk of different color and shapes in Syria and Africa? What are the elements, the winds, the seas? How do our minds work, the planets move, the stars sparkle, the moon shine, and the comets dart through the skies? How are babies made, born, cared for? What do the wise say about all that?" Perfectly legitimate questions, and they are interestingly answered in this little book and often nicely illustrated by appropriate and striking pictures. It pretends to be no more than a catechism of science for the educated layman who liked to read about these things in his vulgar tongue. Nearly fifty incunable editions of this book appeared, in German, Italian, and Czech. There is another *Elucidarius* or

Lucidaire in Latin and French, probably somehow connected originally with this book, but different in context as it is rather a dogmatic manual for clerics. It has been attributed to Honoré d'Autun or to another Honoré le Solitaire, not very convincingly. But it seems certain from the evidence of manuscripts that it is the product of a literary movement which set in after the crusade of the Guelph Duke Henry the Lion, on his return to his faithful spouse Mathilde in Brunswick, then Saxony, in the second half of the twelfth century. Somehow this Mathilde, daughter of Henry II of England and Eleanor of Poitou, seems to have been the center of this movement out of which issued, with this little book, other renowned books such as the *Song of Roland* and *Tristan and Iseult*. The title of the book, as so often, came to be taken as the name of the author and as "Meister Elucidarius" enlightened countless generations until it became more presentable to the sophisticated nineteenth century under the name of *Little Cosmography*.

There are two popular works of the twelfth century, the *Image du monde* of the above-mentioned Honoré d'Autun and the *Philosophia mundi* of Guillaume de Conches (both of which found a feeble reflection on incunabula pages, the first by itself, the other in the great encyclopedia of Vincent of Beauvais, the *Speculum naturale*), which seem to have some relationship with our *Lucidarius*. Schorbach, who studied the *Lucidarius* in great detail, has not been able to decide the matter.[18]

Next in popular appreciation come the incunable *Herbals* already discussed above; they are immediately followed by the *Somnia Danielis*, the most read of the dreambooks and probably of very ancient lineage. The book has been studied carefully by Maurice Helin with particular reference to the incunabula editions, of which he lists thirty-seven editions with excellent facsimiles.[19] I have not studied the book, but from what I hear of it, it might well offer scientific material to work upon, especially to the psychoanalytically-minded.

The *Auctoritates Aristotelis*, which occupy the next place, giving merely brief sentences from Aristotelian and other philosophic works, may be mentioned here only as a measure of the immense popular appeal which the name of the "philosopher" made to that generation, as to many before and after. Very few understood him then as afterward, but they tried to understand him, and that fact alone is significant. The mass of young people who clamored for entrance into the Museum of Natural History in New York, to hear an exposition of Einstein's theory of relativity, signifies a similar interest today.

ARISTOTELES: *Problemata*

From 1473 on, as many editions as those of the preceding books were called for of these *Problems*. They belong to the class of minor writings of Aristotle on natural history, which competent philologists from Renaissance times to ours have considered as spurious. Their transmission came via Sicily, where Graeco-Latin translators were working for King Manfred (1258–66), just as they had done for his father, Frederick II, and his grandfather, the Norman Duke Roger in Palermo, those great patrons of early science. The book, about whose translation Manfred is known to have reported to the University of Paris in 1263, is very similar to some of the works of Michael Scot and of Adelard of Bath, who also were connected with the Sicilian *Curia* at an earlier epoch, and whose works were suitably recorded by the incunabula presses.[20] It is frankly a compilation from Aristotelian and other allied works, and as such it was described by Manfred. Why we should not be able to remember this without prefixing "pseudo" to the great name is difficult to see. The book is most interesting and no doubt was very stimulating, and for that Aristotle would gladly have lent his name. Galen, Seneca, Genesis, Ipocras, Avicenna, Averroes, Albertus Magnus, and the *Regimen sanitatis* of Salerno are cited in it, as in many of the *florilegia* of the time.

Peter of Abano, the great physician and philosopher of the school of Padua of the thirteenth century, is connected with the work, though not as its translator, as sometimes stated, but as its expositor. The press also reproduced this work. The book attempts to explain a number of physical peculiarities of the human body. Such questions as why men grow bald and women not; why hair is sometimes soft, sometimes hard; why fright could raise the hair; why the brain is partly white, partly gray; why it is cold; why man has one nose and two eyes; and many more about various regions and parts of the body—all these questions we are likely to call absurd, probably having answered them satisfactorily.

JOHN OF HOLYWOOD: *Sphaera mundi*

Nobody will dispute the scientific standing of this *magnum opus* of the learned Yorkshireman who usually goes by the name of Sacro Bosco. In this domain of cosmic beatitude there is no strife; as soon as one fixes the orbits of the stars and speaks of them in mathematical terms, one is friend with everyone else who uses the same methods, whether near or far, in space or time. Sacro Bosco was buried anno 1256 at the Mathurins in Paris, and his *Sphaera* rolled on peacefully, leaving traces on the paper of numerous scribes and commentators, and between 1472 and 1647 in some seventy and more editions. We are told that he only restated what Ptolemy and several Arabs had found. At any rate, distinguished men such as Michael Scot, Cecco d'Ascoli, Pierre d'Ailly, Regiomontanus, Le Fèbvre d'Etaples, and many others found it worthy of further commentaries. Not having read the book, or studied its sources, I cannot judge its originality, and am content to note its immense popularity, while I admire the beautiful *editio princeps* of Ferrara (1472) and that other one (1482) of the master-printer of Venice, Ratdolt, who specialized in mathematical and astronomical literature, using even a three-color process for some of his astronomical diagrams.

ANIANUS: *Compotus manualis*

Rivaling with the *Sphaera* of Sacro Bosco in the number of editions, though probably not in the matter of scientific importance, this book has been most interestingly studied by David Eugene Smith,[21] based on the examination of extant manuscripts and a series of some sixty editions printed between 1488 and 1529 (thirty-three incunabula). This little book deals with the ancient concept of time which modern science allows us to dispense with, having recognized that our clocks are nothing but terrestrial speedometers indicating progress in space only. The determination of solar and lunar time, and from that the adjustment in the Christian calendar of the movable and fixed feast days, is done by the clever expedient of using the knuckles of the fingers of both hands as a sort of counters, the meaning of which is indicated on woodcut diagrams of hands. The *Compotus* consists of a text in verse and a commentary in prose. The verse has the familiar leonine jingle of the Salernitan *Regimen sanitatis* which we considered above, also of those didactic medical poems in which Gilles de Corbeil deplored the decadence of medical art in Montpellier under the Arabs and sang of the glory of Salerno. I should suspect its origin in this direction. Smith does not want to decide; he does not know manuscripts earlier than the thirteenth century, but he does not exclude the possibility of some connection with the famous monastery at Aniane founded in Carlovingian times near Montpellier, which, having belonged to the Benedictine order, naturally suggests an influence from Monte Cassino. One thing is certain, that the author was not Alsatian, as some have suggested, merely because the first dated edition of 1488 was printed in Strasburg.

For Haskins "one of the clearest indications of intellectual revival in the early twelfth century is the large number of manuscripts of that period and shortly before which deal with the elements of arithmetical and astronomical reckoning." I should suspect that in that survival rather than revival of the Latino-

Greek tradition the medical production would run a close parallel course with the arithmetical and astronomical, but the great importance of the latter for the evolution of scientific thought must be readily conceded.

The remarkably tenacious hold on the public mind which these primitive but eminently practical treatises exhibit by reappearing in full vigor after centuries in the new presses is a very interesting historical phenomenon. In arithmetic and in astronomy, as well as in medicine, it recalls the humble origin of the sciences, in the practical popular needs. To this field belong also the numerous almanacs, calendars, prognostications, and *judicia* which appeared on broadsheets and in little booklets. Only of almanacs we have more than three hundred different editions. They all offer interesting historical material which has been very little studied.

Regimen sanitatis Salernitanum

Belonging here in the order of popularity, I record it once more because it gives me a chance to say something about the Arabic phase of the great school, whose influence is reflected in the incunabula with emphasis, though in quantity it does not approach the *Regimen*. Constantine the African, who belongs rather to Monte Cassino than to Salerno, by his translations and appropriations, became the great propagator of Greek science, mainly medical, from Arab sources. His name heads no incunable entry (his main work was printed first with Isaac Judaeus in Lyons, 1515), but the *Articella*, a bunch of minor Greek (mainly Galenic and Hippocratic) works, was gathered by him. Then there is the Salernitan *Nicolaus' antidotarium*, which no self-respecting edition of Mesue's pharmaceutical work could afford to omit; not to forget the medical *pandectae* of Matthaeus Silvaticus (10 edd.). Then the very important *Circa instans* of Platearius, whose text in numerous, especially French, manuscripts brought plant illustrations, and became

the textual basis of a long series of printed herbals already referred to. Very important also is the stimulating effect on surgical practice of Salernitan writers, though in the incunabula their works are hidden under the great name of the Frenchman Guy de Chauliac.

PLINY: *Historia naturalis*

Of larger works this is by far the most popular of scientific incunabula, and some of the editions are of the most beautiful of the whole time. Even the humanists, who looked askance on most scientific writing, inclined to damn it as "scholastic" rubbish, took warmly to the *Historia*, though many of them wrote works pointing out Pliny's errors. The book is so well known that I need not go into it here, especially since Thorndike has done it so well in his *History of magic*. I am struck particularly with one remark he made when noting the rambling and discursive, rather than logical and systematic, mode of Pliny's presentation. He said: "I have often thought that the scholastic centuries did mankind at least one service, that of teaching lecturers and writers how to arrange their material." This was indeed a great step and of fundamental importance in the material orientation science was taking, and in this the possibility of a still more lucid and surveyable[22] arrangement, such as the press could provide, no doubt made printing the indispensable vehicle of the scientific thought of the future. On the other hand, it seems true that for the verbal projection of living events the narrative, which *relates*, is more suitable than description, which *dissects*, cutting living relations, and in this Pliny's presentation may have an advantage over our mode.

BARTHOLOMAEUS ANGLICUS: *De rerum proprietate*

With more than seventy editions extending into the sixteenth century, twenty-five incunabula—twelve in Latin, eight in French, two each in Dutch and Spanish (these latter non-Latin

ones most interestingly illustrated), and one in English—must make one think that Bartholomew the Englishman must have led the interests of many people in the direction of natural knowledge. As Thorndike suggests, "Such elementary and popular works are more likely to have survived the stagnant and destructive period of the Black Death and Hundred Years' War and to have come down to us than are the more advanced, original, and elaborate works of the thirteenth century." And Bartholomew in the version of Trevisa says:

> Spryngynge tyme is the tyme of gladness and of love . . . . thynge that seemed deed in wynter and widdered, ben renewed in springing time . . . . and water in spryngynge time is unholesome to drynke . . . . it is infect with frogges and other wormes that then brede. And therefore, if it be nedefull to drynke water that tyme, Constantyne counseyleeth to seeth it first, that it may be clensed and pourged by boyllynge.

I think if I were not allowed any other books, I could be quite happy with Pliny and Bartholomew alone.[23]

MESUE: *Opera medicinalia*

We do not seem to know who Mesue was, for no Arabic manuscripts of his work have been found. It may be that like the medieval founder of chemistry, "Geber," who cannot be identified with the ninth- or tenth-century Jabir, or the "Apuleius" of the *Herbarium*, who cannot be the African mystic, "Mesue" stands also as an eponymic reminder of the collective scientific activities of just those early medieval epochs when craftsmen were uniting their own and others' experiences. Mesue is the pharmacological Bible of many long generations. It was indispensable as a guide to the many new drugs and compounding manipulations to which the Arabs were introducing the Western world. Even the humanists who scoffed at the oriental *filosofandi aviditas* had to accept the odoriferous gift, and it is interesting that the two *editiones principes*, for there are two, were printed in a matchless Roman *humanistica* type, from presses that are still puzzling bibliographers. One evidently belongs to

the Venetian printing sphere, though probably not to Venice itself, to which it is traditionally assigned. No one knows much about the indicated printer, the "good priest Clemens of Padua," to whom we are introduced in the prefatory letter of Niccolò Gupalatini to the Veronese physician Peregrino Cavalcabovi (who had printing relatives in Verona) under date of "Venetiis 1471," the fifteenth calends of June. Patriotic Italians have hailed him *unbekannterweise* as the first native printer. It being his only book, it would seem that three towns might claim to be its press place. Then the other *princeps:* It is fully dated but without indication of place: 1471, the fifth ides of June, and of no personalities whatever. Close-running and puzzling, indeed: Scholderer in Osler, *Incunabula medica*, No. 10, put it to Venice or Florence with two marks of interrogation, but just lately he has decided to assign it definitely to Florence (*British Museum catalogue*, VI [1930], 615), where it heads the list of books printed in the fifteenth century, and where I have put it intuitively long ago, for with its special type of *humanistica* it could not have gone anywhere else. But these are details and the main question remains unsolved, open to all bibliographers: Who printed this, the earliest, the most important specialistic and therefore most modern scientific incunable? The question embraces both *editiones principes*. As regards the claim that Clemens was the first native Italian printer, we cannot allow it, for Lignamine the Messenian at Rome printed his Sueton in 1470 *mense sextili*.

HIPPOCRATES: *Aphorismi, etc.*

He comes rather late in our list of "best sellers" and not even with the *Opera omnia*, which in Greek Aldus brought out only in 1526, and in Greek-Latin the Junta only in 1588. But the true Hippocratic spirit, that essence of medical common sense which is of all ages, we have already found in that inconspicuous literature beginning with Salerno. Scholars knew it by heart

in the easy cadence of rhymes they loved; it was the medical craftsman's conscience that kept him straight when complex problems came in bewildering multiplicity. So we have to go with a microscope through the incunabula pages to find the learned taking notice of him. Jacob of Forli, who at the high school of Padua about 1380 had been as *alter Hyppocras* in charge of the matutinal *lectura* on the aphorisms, is the first, with the *expositiones* developed then, to appear on the penultimate day of October, 1473, in the fine Roman script of an unknown press in an unknown place, similar in form to those of Jenson's but not his—another puzzle for bibliographers to solve.

Other of the Hippocratean incunabula deal, *horribile dictu*, with dreams, the nature of man, the physician's astrology, of prognostics, the "ivory capsule"—trifles perhaps for the one who prefers his Hippocrates in Littré's fine edition of 1839 in ten volumes, gems to some others who like to read what part of the thought of a great man had enduring validity in the eyes of the many. But of course there is nothing in the whole literature of science like the wise words of the aphorisms, with its sonorous *incipit* that still vibrates through the world: "Life is short and art is long"; "Occasion is fleeting, experience fallacious, judgment difficult."

Rhasis: *Liber IX ad Almansorem, etc.*

Medicine and science will have to be always grateful to the Arabs for having brought down to us this great Persian. He could not compete with his great textbook-writing compatriot, Avicenna, in the massiveness of production and appeal to school men, but for truly scientific method and insight it would be difficult to find his better. Sarton is quite right to label his chapter on the second half of the ninth century "The time of Al-Razi," for there was surely nowhere in the world so universal a scientific thinker as Rhasis at that time. And still we do not know yet with any amount of precision in what field lay his greatest contribution. It looks as if the chemists had more

claim on him than any other scientists, and since it is in this field that Arabic science probably made its most important and most original contribution to the West, we ought perhaps not to insist too much on his reputation as a clinician. But this he was undoubtedly, and as such he appears in the incunable literature, as fresh, clear, and wise as he was five hundred years before. He is always called a Galenist, and theoretically of course he was, but with erudition carried so lightly and wisdom shared so freely he resembled little the cantankerous high-brow who kicked every colleague passing his shop on the Via sacra.

Rhasis' first commentator was Gianmatteo Ferrari da Grado of Pavia, grand-ducal archiater and great light of medical scholasticism of the complex brand. Osler, who had a manuscript consultation by him, after reading it thought it must have been a "formidable thing" to fall into the hands of a medieval physician. But one great merit Ferrari had—he was the first physician of whom we have record who personally arranged for the printing of his *opus*, and we even know what it cost him. It saw the light of day, as I have shown elsewhere, before October 29, 1472.

It is often said that the Arabs, on the whole, stopped scientific progress. How much they really contributed to the education of our forbears is well illustrated by the case of the undisputed medical reformer, the great Vesalius. As he tells himself, one of his distant ancestors, Peter, wrote a commentary on one of the fens of Avicenna, his grandfather did the same for Rhasis, and he himself for his scientific début wrote a paraphrase on the same book (1537), using Eberhard's text to help him.

GALEN: *Ars parva* (*microtechne*)

Last but not least in my list of public favorites is the great Galen. Neuburger writes about him and I translate freely: "In him Greek medicine reaches not only its second apogee, but its epistemological conclusion, and, fundamentally, the whole preceding development has no other significance than that of a gi-

gantic intellectual process, which transformed the Hippocratic *art* into the Galenic *science*."[24] This sums up poignantly what I took long to extract from the incunabula, from those first machine-made products of a collective mentality, striving toward machine-like precision and toward that materialistic perfection which our science seems about to have attained.

Thus I see the past and the present. But is this present perhaps already the past? A few days ago Sir James Jeans in his Rede Lecture on "The mysterious universe" said at Cambridge: "To-day there is a wide measure of agreement, which on the physical side of science approaches almost to unanimity, that the stream of knowledge is heading towards a non-mechanical reality; the universe begins to look more like a great thought than like a great machine."[25]

Notes

1. As I write this, an interesting page in *Science*, LXXII (1930), 318, catches my eye. In the left column a scientist from Iowa says, among other things, "The end of all science is classification . . . . ," and to this, in the right column, another correspondent from North Carolina, speaking from a viewpoint unconnected with the subject discussed by his confrère, seems to make an unwitting answer when he reports that he has collected from the literature on insects of the order Homoptera about 150,000 references to about 30,000 species distributed in 5,000 genera. And he adds, presumably with a sigh, that one hundred and seventy-two years ago Linné had described 1 genus and 42 species of this same group of insects.

2. George Sarton, *Introduction to the history of science* (Washington, 1927), p. 34.

3. William Osler, "Chauvinism in medicine," in *Aequanimitas and other addresses* (Philadelphia, 1904), p. 280.

4. It is impossible to make a quantitative comparison of the entire scientific productivity in incunabula times and in ours. But a juxtaposition of some figures available from allied scientific fields to those from incunabula literature is impressive. For approximately the same length of time (thirty-five years) the Concilium Bibliographicum at Zurich (director, Professor J. Strohl) has collected up to 1929 for six specified fields of scientific research a half-million titles of works by about half the number of authors.

FIFTEENTH-CENTURY PRESSES	TITLES
Natural philosophy . . . . more than	215
Astronomy, astrology	185
Medicine	410
Technology	120

CONTEMPORARY PRESSES	TITLES
Paleontology	39,900
Biology	7,345
Micrology, etc.	4,186
Zoölogy	356,350
Anatomy	37,641
Physiology	68,924

This gives a very small fragment of modern scientific thought in juxtaposition to the totality of what may be called scientific thought at the end of the fifteenth century.

5. Those engaged in scientific work know the great stimulating effect they receive from every improved instrument. Each seems to enlarge the world, and we have faith that our knowledge will increase in proportion to the enlarging power of our microscopes or the farther reach of our telescopes. There may be limits, but at any rate we do not anticipate them.

6. Though dwelling mostly on the lyrical side of their activities, Miss Helen Wadell has recently discussed them in a most attractive book, *The wandering scholars*. London: Constable, 1927.

7. A. C. Klebs, "Gianmatteo Ferrari da Gradi and the *editio princeps* of his *Practica*," *Essays presented to Sudhoff* (Zurich, 1924), pp. 211–36, and Klebs-Sudhoff, *Die ersten gedruckten Pestschriften* (München, 1926), pp. 85 ff.

8. Whitehead has lately (*Vanuxem Foundation lectures* [Princeton, 1929], p. 33) drawn attention most interestingly to the fact that until the most recent period it would be difficult to discern any influence of speculative reason upon the evident progress technology has made during the last three thousand years. He sees in the enormous advance of technology in the past one hundred and fifty years the final contact made by speculative reason with practical reason. "The speculative reason has lent its theoretic activity, and the practical reason has lent its methodologies for dealing with the various types of facts. Both functions of reason have gained in power. The speculative reason has acquired content, that is to say, material for its theoretic activity to work upon, and the methodic reason has acquired theoretic insight transcending its immediate limits. We should be on the threshold of an advance in all the values of human life."

9. Even in a relatively unimportant matter like the spelling of proper names of authors and printers, and of towns and countries, a great deal of trouble is experienced when one tries to be consistent. My beau ideal is to spell all these names the way they would be spelled by those most concerned in their vulgar tongue and not in Latin or any other language. It corresponds to the desire of the best scholars in the various lands, but it simply cannot be carried through with absolute consistency. All we can do is to follow as far as possible the direction indicated, without upsetting too much very old and deeply fixed habits. Quattrocento people were not as particular about spelling as we are, and for that reason alone a certain amount of arbitrary choice has to be used. As regards town and country names I have on the whole adhered to the English usage, although I always feel that Proctor's adoption of local forms was much the fairer way. Somehow *Padua* comes easier than *Padova*, and *Cologne* easier than *Köln*, but since not even the *British Museum catalogue*, the chef d'œuvre of incunabula bibliography, follows Proctor's lead, I follow sheepishly its example.

10. Henry Osborn Taylor, *The mediaeval mind* (Macmillan, 1911), I, 14–15.

11. *Geschichte der lateinischen Literatur des Mittelalters*, II (1923), 726.

12. Leonardo Olschki, *Die Literatur der Technik und der angewandten Wissenschaften vom Mittelalter bis zur Rennaissance*, I (Leipzig, etc., 1919), 13.

13. Ten incunable editions mostly from Augsburg between 1472 and 1495: Hain 13736, etc.

14. Charles Daremberg, *Introduction: L'école de Salerne en vers français* (Paris, 1861), p. lvi.

15. Charles Singer, *Studies in the history and method of science* (Oxford, 1921).

16. In "Herbals of the fifteenth century," *Papers of the Bibliographical Society of America*, Vols. XI–XII (1917–18), I have studied in detail the incunable series of the

various illustrated herbals. The list which I established then comprises some forty editions, and it has since not needed any important revision.

17. *A history of magic and experimental science.* 2 vols. London: Macmillan, 1923.

18. Karl Schorbach, *Studien über das deutsche Volksbuch Lucidarius und seine Bearbeitungen in fremden Sprachen.* Strassburg: Trübner, 1894.

19. Helin, *La clef des songes*, forming Tome III of *Documents scientifiques du XV^e siècle.* Paris: E. Droz, 1925.

20. About these important contributors to early science see also Thorndike in the work cited and especially the masterly introduction by C. H. Haskins to this epoch, in his *Studies in the history of mediaeval science* (Cambridge, 1924; 2d ed., 1927).

21. D. E. Smith, *Le comput manuel de Magister Anianus*, forming Tome IV of *Documents scientifiques du XV^e siècle.* Paris: E. Droz, 1928.

22. I see that there is no other but this mongrel word to express the much-needed sense of the German *übersichtlich.* Apparently only Carlyle found it necessary.

23. Thorndike's account of the book is admirable (Vol. II, chap. liv), and the abstracts from it in *Social life in Britain from the Conquest to the Reformation* (compiled by G. G. Coulton; Cambridge University Press, 1919) provide an excellent introduction to this remarkable book.

24. Neuburger, *Geschichte der Medizin* (Stuttgart, 1906), I, 354.

25. *London Times*, November 5, 1930, p. 15.

MUSIC AND MUSIC PRINTING IN INCUNABULA

By Otto Kinkeldey

THE question of music in the fifteenth-century book has a double aspect. There are books about music, and books which contain musical compositions. The former class differs in no respect from books on any other topic except, perhaps, in so far as the discussion of music often involves the use of specimens or passages of actual musical compositions to illustrate the writer's meaning. As we shall see presently, this need presented a special problem to the writers, and more particularly to the printers of books about music. The problem of printing musical notation proved even more serious for the makers of books containing large quantities of music destined for practical performance.

Let us consider first the question of the contents of books about music in the incunabula period. In discussing the character of these works we may naturally inquire into the place of such books in the general scheme of human knowledge or learning, as it had developed in the second half of the fifteenth century. What relation did the art of music bear to the other arts, to literature, and to intellectual activity in general?

The Middle Ages and the Renaissance had inherited from antiquity an attitude toward music which assigned to this art a definite and a not insignificant place in the scheme of education. The fondness of medieval writers for systems, particularly for systems based on the mystical number 7, will afford us a clear understanding of how they fitted music into their scheme of human knowledge or thought. Thus we find one grouping of

the "seven sciences" with music included in a very illustrious company. These sciences were mathematics, geometry, astronomy, music, ethics, physics, and metaphysics. Another classification, with its twofold division of trivium and quadrivium, was in vogue in the Middle Ages under the denomination of the "seven liberal arts." The trivium included grammar, dialectic, and rhetoric. The quadrivium embraced arithmetic, music, geometry, and astronomy.

It will be observed that in each of these two general classifications music is closely allied with mathematics. The student of the history of musical literature soon realizes that the authors on musical theory at any rate (and they constitute by far the greater number of those who wrote about this art), treat the subject as if it were a branch of mathematics. Following the example of the Greeks, for whom the whole subject was initiated by Pythagoras, the medieval writers generally give us lengthy, at times wholly mathematical, analyses of the theory of music. This is true of the sixth-century Boethius, who wrote on arithmetic, music, and geometry, and whose five books on music were regarded as a kind of musical Bible for at least ten centuries; and it is equally true of the late fifteenth-century Jacques Lefèbvre d'Étaples (Faber Stapulensis), who has likewise left us writings on arithmetic and on music. We meet with both these authors in our incunabula.

Of more direct interest than this general inquiry as to the place of music among the arts or the sciences is the question as to how many books on music we may expect to find among the incunabula, and what relation they bear to the general mass of printed books of the time. An attempt to answer this question was made some twenty-seven years ago by Robert Steele, whose work on *The earliest English music printing* (15)[1] is one of the most striking contributions to the splendid series of publications of the Bibliographical Society of England. To a series of articles on "What fifteenth century books are about" (16), published

from 1903 to 1907 in the London *Library*,[2] Steele prefixes a general statistical survey of the whole field, based on a count of the titles enumerated in Proctor's Index of the incunabula in the British Museum.

That the greater proportion of the fifteenth-century printed books lie in the fields of theology (including editions of the Bible), of the law, canon and civil, and of belles-lettres is well known. Steele's table informs us about the relative frequency of books in other fields, particularly in the sciences. His figures are shown in the accompanying tabulation. Books on music,

Medicine	247	Natural history	33
Occult sciences	93	Mathematics	24
Astronomy	81	Arms	19
Physics	77	Agriculture	18
Cosmography	76	Music	12
Calendars	71	Hunting	6
Encyclopedic	41	Navigation	1
Itineraria	39		

we see, occupy a comparatively modest place. To be sure, the twelve books on music counted by Steele in the British Museum do not include all books on this subject published in the fifteenth century. But the relative proportions are probably correct.

A more nearly complete census of incunabula about music is provided in the list given by Johannes Wolf as a supplement to his facsimile edition and translation into German of Francesco Caza's *Tractato vulgare de canto figurato* (Milan, 1492) (2). This facsimile was published in 1922. Wolf's census increases the number of books about music from Steele's twelve to one hundred and three, including fourteen undated items. The list embraces a number of works in which music forms only a portion of the subject matter, but it gives a clear idea of the nature and the contents of the works listed.

Some of the encyclopedic works, whose compilers are still under the influence of the ancient or the medieval classification

of knowledge or theory of education, make a special point of discussing the art of music, at any rate in its scientific, theoretic aspect. The early seventh-century *Etymologies* of Isidore of Seville, for example, are a mine of information for the student of medieval music. The first printed edition of the *Etymologies* appeared in Strasburg about 1472, and Wolf lists eight other editions before 1501. The very popular thirteenth-century encyclopedia of the Englishman, Bartholomaeus Anglicus, *De proprietatibus rerum*, likewise contains a brief section on music. Between *ca.* 1472 and 1501 at least twenty-two editions of this work were printed.

Bartholomew's book seeks to provide for the needs of the preacher and the teacher, who require information on the terms and allusions of the Bible for their general didactic purposes. The nineteenth and last "book" of the voluminous compilation concludes with fifteen chapters, some of them merely brief paragraphs, *de sonorum proprietatibus et differentiis*. Most of these chapters are devoted to descriptions of musical instruments, since many of them are mentioned in the Bible. Bartholomew's chief authority is Isidore.

Another old writer whose works were considered worthy of a printed edition in the fifteenth century was the fifth-century poet and scholar, Martianus Capella. His large work, *De nuptiis Philologiae et Mercurii*, is really an encyclopedia of the knowledge and culture of his time. The first two books are devoted to an allegorical description of the nuptials of Philology and Mercury. Each of the remaining seven books is a wedding gift of one of the seven arts to the learned couple. Book IX is the contribution of Music. It is characterized by long excerpts from the writings of a Greek musical theorist, Aristides Quintilianus, who lived in the first or second century of our era. The extracts deal with intervals, scales or modes, with the characteristics of melodies, and related questions. The work of Mar-

tianus was first printed in 1499 in Vicenza by Henricus de Sancto Urso.[3]

Two works by Theodorus Gresemundus treat of music as one of the seven arts. They are *Lucubraciuncule bonarum septem artium liberalium* (Mainz: Petrus Fridebergensis, 1494) and *In septem artium liberalium defensionem dialogus* (Deventer: Jacob de Breda, 1497). Another encyclopedia, the famous *Margarita philosophica* by Gregory Reisch, was first printed in 1495 or 1496. The woodcut which serves as a frontispiece to the section on music has often been reproduced.

If we deduct these encyclopedic works and some others in Wolf's bibliography, in which music is not the sole or main subject of the book, we find thirty-seven items which might be regarded as strictly musical. It is this smaller group which should be considered in making a comparison between the figures of Steele and of Wolf in order to estimate the rate of progress made by studies in this field. The thirty-seven may be divided roughly into two classes: first, those which deal with the subject in a strictly scientific way, treating music as a branch of mathematics and devoting themselves chiefly to a systematic and sometimes highly complicated discussion of the number ratios for all musical intervals and of the structure and mathematical foundation of ancient or medieval scales and modes, which were still in use during the incunabula period; and, second, those that had a more practical purpose, seeking to teach the method of singing, particularly the practice of plainsong, the orthodox Gregorian music of the Roman church, or attempting to explain the rules and practice of counterpoint and the complex system of notation which had grown up with the development of contrapuntal technique. The aesthetic speculation, the belletristic commentaries or guides for laymen, which bulk so large in the musical literature of the present day, are practically entirely absent. One might have expected that the works of the great Boethius, whose *ipse dixit* carried as much weight with medieval

musical writers as that of Aristotle did with the philosophers, would be among the earliest to be printed. But he comes rather late in the list of musical incunabula. The *editio princeps* of his *De musica* is dated 1492. It was printed by the brothers De Gregoriis in Venice.[4]

The earliest special work about music among the printed books now known is Conrad von Zabern's *Opusculum valde singulare et rarum, noviter cum magna diligentia collectum tractans de octo nota dignis usibus sive utilitatibus instrumenti musici dicti monochordum*, printed in Mainz by Fust and Schoeffer about 1462. The author was a preacher and professor of theology at the University of Heidelberg who also lectured on music. The little tract of twelve leaves belongs, as its title shows, to the mathematical group, for it discusses the use of the monochord, an instrument with one string running over a graduated scale, used for studying interval relationships and scale construction. The same writer is responsible for one of the practical treatises on plainsong. It is entitled *De modo bene cantandi choralem cantum in multitudine personarum opusculum rarissimum novissime collectum anno Domini M ccccl xxiiij*.[5] Like the earlier work, it was printed by Fust and Schoeffer.

Our next author is one of the shining lights among the musical theorists of the Renaissance. Franchinus Gafurius (1451–1522) was professor of music in Verona, Naples, and Milan, choirmaster at the Cathedral of Milan, and, in 1498, lecturer on music at the University of Pavia. His writings, based on the teachings of Boethius, cover the whole field of musical theory, its mathematical aspect, the theory of notation, and the rules of counterpoint. In the list of incunabula he is represented by the *Theoricum opus armonice discipline* (Naples: Franciscus de Dino, 1480). Another version of this work was published under the title *Theorica musice* (Milan, 1492). His *Practica musice* was printed in Milan in 1496 by Guillaume Signerre, of Rouen. Other editions followed in 1497, 1502, and 1512. These books

were written in Latin, whereas the *Angelicum ac divinum opus musice* (Milan, 1496) is an exposition of his theories in Italian.

The greatest contemporary of Gafurius was the Spaniard, Bartolomeo Ramis de Pareja, who taught first in Salamanca, then from 1480 to 1482 in Bologna, and after that, at least until 1491, in Rome. The one authentic work of Ramis de Pareja, *Musica practica* (Bologna: Baltasar de Hiriberia, May 12 and again June 5, 1480), made a deep impression upon his contemporaries. Ramis, by his emphasis upon and special study of the proper interval ratios of the major and the minor third, laid the foundation for the modern theory of harmony.

The two great theorists of the period, Gafurius and Ramis de Pareja, never engaged in a direct polemical encounter, but certain utterances of the Spaniard, such as, for example, his proposal to replace the six-syllable hexachord system, developed by Guido of Arezzo in the eleventh century, by an eight-syllable octave division, aroused critical opposition.[6] In one printed fifteenth-century book this opposition took a very outspoken form, which is evident even in the title. In 1487 Nicolaus Burtius (Nicolo Burzio) of Parma published a work entitled *Musices opusculum incipit: cum defensione Guidonis Aretini: adversus quendam Hispanum, veritatis prevaricatorem* (Bologna: Ugo de Rugeriis).[7] Giovanni Spataro of Bologna, a pupil of Ramis, countered with *Musices ac Bartolomei Rami Pareie, ejus preceptoris, honesta defensio in Nicolo Burtii Parmens. opusculum* (Bologna: Plato de Benedictis, 1491). Gafurius himself entered the lists to ward off this attack with an *Apologia* against "Spataro and his musical accomplices in Bologna." The work was not printed until 1520 in Torino.

This lively tilting was, of course, only a small part of the activity of musical authors and publishers. The field first entered by Conrad of Zabern with his *De modo bene cantandi choralem cantum* (1474) was cultivated by others. We shall single out two little-known works from the Spanish literature

on the subject. Konrad Haebler includes, in his catalogue of Spanish incunabula, a work by Marcos Duran, printed in Seville in 1492 by *cuatro alemanos compañeros*. It bears the title *Ars cantus plani composita brevissimo compendio "Lux bella" nuncupata*. It consists of fourteen unnumbered leaves, and its *incipit* shows that it deals with the "octo toni artis musice a patre sanctissimo Gregorio ordinati et compositi qui quodam modo sunt claves musice artis." All the eight leaves of gathering *b* contain printed music, such as we shall discuss later. The music is printed on six staves of five lines each with the words below. Haebler does not explain the process by which the music was printed, but he believes that this is without doubt the first book printed in Spain that contains printed music.[8] The book received a commentary by Domingo Marcos Duran, apparently a son of the author of *Lux bella*, who is here called Juan Marcos Duran. The title of the commentary is *Glosa sobre "Lux bella,"* and it was printed in Salamanca in 1498 by the *segundo grupo gótico*. It consists of thirty-eight unnumbered leaves and also contains printed music.[9]

The remaining authors of theory books we shall list briefly, including in one list both the writers on plainsong and those who wrote about mensural music, the *cantus figuratus*.

1488 Spechtsart, Hugo, von Reutlingen. *Flores musice omnis cantus Gregoriani*. Strasburg: Johann Prüss.

1492 Caza, Francesco. *Tractato vulgare de canto figurato*. Milan: Leonard Pachel for Joanes Petrus de Lomacio.

1496 Keinspeck, Michael. *Lilium musice plane*. Basle: Michael Furter. Other edd.: Basle: Joh. Schäffer, 1497; Augsburg: Joh. Froschauer, 1498, and again 1500.

1500 Bonaventura de Brixia. *Regula musicae planae*. Milan: Leonard Pachel for Johannes de Legnano.

1501 Balthasar Prasbergius. *De musica chorali liber*. Basle: Michal Furter, 1501, also 1504, 1507.

Other authors wrote about the origin of music or made comments of a more general character on this art. Among them were:

1488 Tinctoris, Joannes. *De inventione et usu musicae.* Naples: Francesco del Tuppo.

1491 Jacobus de Reno. *Tractatus brevis . . . . in laudem musice artis et de eius utilitatibus.* Antwerp: Gerardus Leeu.

1495 Guillermo de Podio. *Ars musicorum sive commentarius musice facultatis.* Valencia: Peter Hagenbach and Leonard Hutz for Jacob de Villa.

1499 Anon. *Compendium musices.* Venice: Giovanni Battista Sessa.

1500 Bonaventura de Brixia. *Breviloquium musicale.* Brescia: Angelus Britannicus.

As the last item in this brief survey we mention a very useful and striking work, the earliest real dictionary of musical terms. Its author is the Fleming, Joannes Tinctoris, already cited as the writer of a tractate on the invention and the use of music, who was born in 1445 and died in 1511. He was sometime chapel master of Ferdinand of Aragon at Naples, and later a canon of the Cathedral of Nivelles. His *Terminorum musicae diffinitorium* was printed without a colophon and used to be assigned by musical scholars (Fetis and others) to the year 1475 or thereabouts. Later researches, however, seem to have fixed a date *ca.* 1495 and revealed the printer as Gerardus de Lisa at Treviso. Written in Latin, it defines about two hundred and eighty-eight different terms, but it appears that the work never became well known during the life of the author or immediately afterward.[10]

Music Printing in Incunabula

As was pointed out at the beginning of this article, the actual printing of musical notation presented a problem that puzzled the ingenuity of printers for nearly half a century after the invention of the art of printing. It is a striking fact that the first successful printer, Gutenberg, solved his problem completely. His best-known works did not lie in the domain of trial and experiment. For centuries after Gutenberg no fundamental change was made in the technique of printing. But the art of printing musical notation with type was a subject of experiment until well into the sixteenth century.

The reason for this is easily grasped. Words can be printed with a font of about twenty-six small letters and the same number of capitals, with a small number of additional characters and punctuation marks. Musical symbols are written on a staff of four or five continuous horizontal lines, and the characters for the notes must be placed accurately at varying heights, so that they fall exactly on the right line or in the right space. The difficulty is increased by the necessity of using variously shaped note heads to indicate different rhythmic or time values. For the printing of liturgical music, the plainsong of the church, a comparatively small number of different note shapes suffice; but for mensural music of the contrapuntal type in vogue during the incunabula period at least six or seven different shapes, and the same number of signs for rests, were required. This need, combined with the problem of printing the horizontal staff, would increase the number of characters in a font of type and the difficulties of typographical composition far beyond the exigencies of ordinary letterpress work. Added to this was a difficulty which arose from a peculiarity in the musical notation of this early period, by which several notes of different pitch, intended to be sung to one syllable of the text, were combined into one figure, involving the use of oblique lines across the staff. These combinations, called "ligatures," offered a particularly difficult problem for solution with movable type.

The writers on musical theory, particularly those who wrote about notation or the rules of counterpoint, needed actual illustrations in musical notation. Some of their printers avoided the difficulty by simply leaving blank spaces on the page, which were afterward filled in by hand, like the decorative initial capitals of many early printed books. This was the case with Gafurius' *Theoricum opus* (1480), with Ramis de Pareja's *Musica practica* (1482), and with Francesco Caza's *Tractato vulgare de canto figurato* (1492). Copies of some of these books exist in which the blank spaces were never filled in.

This procedure could, of course, never be satisfactory. It was absolutely necessary to find a method of getting music into print. The very earliest effort thus far known occurs in a work which is not specifically musical. In 1473 Conrad Fyner in Esslingen printed an edition of J. Charlier de Gerson's *Collectorium super Magnificat*, a commentary or mystical interpretation of the text of the "Song of Mary." The author, in one passage, makes a musical allusion involving the use of the syllables sol, fa, mi, re, ut. He intended to give his reader a picture of the five notes in a descending scale, but the printer could come no nearer a realization of this illustration than is given by a properly spaced descending row of five black squares preceded by a letter *f* as an F-clef. The lines of the staff were not printed. They were left for addition by hand. Riemann (10, p. 41) states that copies exist in which the whole space is left blank, and that the black squares were later added by the use of hand stamps. In the copies known to him, containing the black squares, the lines were variously added by hand in black or in red ink. Mantuani's (7) accurate measurements prove beyond doubt that the black squares were printed with type together with the letter text, and that the squares were probably produced by reversing the type of some capital letter. The same observation was made by Littleton (6, p. 5).[11]

A similar staffless method is adopted in the Latin grammar of Franciscus Niger, the *Grammatica brevis*, printed in Venice in 1480 by Theodorus Francus (Theodor von Würzburg).[12] The author illustrates the rhythms of five different poetic meters with the aid of musical notes. The five metrical types are: (1) *heroica gravis*, (2) *heroica bellica*, (3) *elegiaca*, (4) *sapphica*, (5) *lyrica*. The verses are selected from Virgil, Lucan, Ovid, and Horace. The musical notes are printed over the words with type made from well-cut dies in three species, the *longa*, the *brevis*, and the *semibrevis*, in the mensural forms current at that time. The vertical spacing of the note heads is so

carefully adjusted that it is a simple matter to draw staff lines through them and thus reveal the exact melodic line. It does not become clear whether the author actually intended these note combinations to represent true musical melodies. It is possible that he was concerned only with accurate rhythms and meant the higher and lower positions of the notes to show merely the rising and falling inflections of the voice in speaking the verses. The fact that a C-clef is printed before the rows of notes seems to imply a true musical notation. If they are really musical melodies, we have in this book the earliest-known specimens of type-printed secular music. But be that as it may, Niger's staffless notes cannot be regarded as a solution of the typographical problem.[13]

One other unusual attempt at inserting musical illustrations in a printed text might be cited here. Wynkyn de Worde, who in 1530 produced the first musical songbook in England, the beautifully executed *XX songs* of which only the bass part is known (facsimile in Steele [15], Fig. 6), made a very ingenious arrangement of rules, dashes, and black squares (raised quads or reversed capitals) to illustrate on a staff of eight lines the four consonances of Pythagoras mentioned in Ranulph Higden's *Policronicon* (Westminster, 1495).[14] But this, like the illustration in Gerson, could hardly be considered music printing.

It is evident from these examples that there were some printers who were really anxious to satisfy the needs of the musician, and were ready to make experiments, even if the results were not very promising. Other craftsmen resorted to a method which was not unknown to some of the earliest letterpress printers, and which had been used with success for the production of pictorial illustrations. The carved wood block, or perhaps even a metal block, was called into play.[15]

The block, so cut that the lines of the staff and the shapes of the notes stood out in relief, was locked in the form with the letterpress and the whole page was easily printed with one im-

pression. The earliest-known specimens of this character are found in Burtius' *Musices opusculum* (1487). The work of Burtius is divided into three parts. In the first part, which deals with the hexachord system, he provides three musical illustrations. The first is the hymn "Ut queant laxis" on five lines. The others are systematic arrangements of hexachords and of tetrachords on eleven lines. Part II deals with counterpoint, and provides the reader with a complete little composition in three voices. The last part deals with notation and presents specimens of note forms and of ligatures. All these illustrations are rather clumsily done on wood blocks.[16]

Another theoretical work which provides musical illustrations on wood blocks is the *Flores musice omnis cantus gregoriani* by Hugo Spechtsart von Reutlingen, printed by Johann Pryss in Strasburg in 1488. In several chapters, of which those *de modis* and *de tonis* occupy the greater part of the book, the whole practice of plainsong is discussed with copious musical illustrations. The melodies are noted on a five-line staff in the angular note forms known as Gothic neumes. Sixty-seven pages contain music, most of them full-page cuts. They are followed by a short illustration of the hexameter rhythm printed on four lines with mensural note forms—*semibreves* and *minims*. In quantity, at any rate, this was a respectable performance for an early printer.[17]

Other theoretical works in which wood (or metal?) blocks were used for music are: the second edition of Gafurius' *Theorica musice* (Milan, 1492); the first edition of the same author's *Practica musice* (Milan, 1496); Michael Keinspeck's *Lilium musice plane* (Basle, 1496);[18] and Gregory Reisch's *Margarita philosophica* (Heidelberg, 1496). In connection with these books we should bear in mind the works of the two Durans in Spain (see p. 96).

The last two pages of Marcellinus Verardus' *Historia Baetica*, a drama on the conquest of Granada, performed in Rome in

1492 (Rome: Eucharius Silber, 1493), contain a musical composition sung in the performance of the play, printed from wood blocks in mensural notes on a five-line staff. This seems to be the first secular music printed in Rome.[19]

The use of woodcut music in combination with a text printed with type was not abandoned as soon as a method of musical-type printing was invented. The little song- or hymnbooks made by Martin Luther for popular use from 1523 onward were in several cases provided with melodies cut on wood blocks. A piece of *de luxe* printing from wood may be seen in Benedictus de Opitiis' *Lofzangen te Eere van Keizer Maximilian* (Antwerp: Jan de Gheet, 1515), in which the text, a number of elaborate pictures, and several lengthy musical compositions (eighteen pages of music) are all printed from beautifully cut, large folio-sized wood blocks. A handsome facsimile of this work was published in 1925 by the house of Nijhoff in the Hague.

Liturgical Books

It is quite clear that the writer of a book about music was not in a very satisfactory position with regard to his musical illustrations during the incunabula period. The question naturally arises as to how the practical musician fared when it came to books made up entirely, or in large part, of musical compositions destined for practical performance. It may be stated that, generally speaking, this need for printed music-books was not really satisfied, with the exception of a special narrow field, until after the beginning of the sixteenth century. Before the year 1500 singers and players were constrained to read their music out of manuscript books, as they had been doing for centuries. But the art of printing was being applied to one type of book which had proved to be either an expensive necessity or perhaps a profitable article of commerce. Theological treatises and books on the law might be used by a reasonably large but nevertheless a naturally limited class of readers. But the

books containing the offices of the church were needed in large quantities. They had formed a large proportion of the books produced in the manuscript age, and among the manuscripts, the missals, containing the priestly portion of the celebration of the chief office of the church, and the books containing the music to be performed by others than the celebrant, or by the professional choir which was employed for more elaborate services, the graduals and antiphonaries, were often the objects of great elaboration and artistic effort on the part of scribes, rubricators, and illuminators.

As long as a practical way of printing music in large quantities remained unknown, graduals and antiphonaries could hardly become a field for successful publishing. But the missal was a practical necessity, and the musical performances of the priest were comparatively small as against the quantity of letter text devoted to prayers, lections, and rubrics. If a method could be devised by which a reasonable amount of music could be added to the large quantity of letter text, the commercial value of the books would be greatly increased. This would apply not merely to missals, but to all liturgical books in which there was much text and comparatively little music.

The first step toward providing such books was exactly the same as in the books on musical theory. The printer printed his text and left blank spaces for the later addition of manuscript music. The earliest document of this kind now known, and probably the earliest in fact, is the famous *Psalterium*, printed by Fust and Schoeffer in Mainz in 1457.[20] The colophon is printed in red, and the book is the earliest known example of two-color type printing. The use of this process, which, of course, merely followed the custom of writing the rubrics in manuscript liturgical books in red, was to have a special musical application, as we shall see presently.

The Psalter contains the words of the psalms as used chiefly in the vesper service and the minor offices of the Roman church.

In the liturgy they are associated with hymns and antiphones. For the first line of music of such hymns or antiphones, or for the opening phrase or a characteristic closing formula (*evovae*) of the tune or chant, the 1457 Mainz Psalter leaves a space at the head of the proper psalm. This first Mainz Psalter was followed by later editions, but not until 1490 did the printer, Peter Schoeffer, provide type-printed music for this book. Several editions later than 1490 are again without music. Other works printed by Schoeffer in the early nineties contain music, but he seems to have abandoned musical typework in his later publications. In one of his books, an undated *Agenda ecclesie moguntinensis*, Schoeffer actually resorts to coarse wooden-block printing to supply the music.[21]

The early practice of leaving blank spaces continued to be followed in liturgical books all over Europe, even after printed music had become common. Many copies still exist in which the blank spaces were never filled.

The next step toward providing the office books with music was not, as in the case of the theory books, the use of block printing. The printers sought to make the matter more convenient for the musical collaborator by providing him with a printed staff. A set of four or five lines without notes was printed with the aid of rules in the blank spaces destined for musical notation. Since the liturgical books had early adopted the two-color method (it spread rapidly after 1460), the printers again followed the practice of the medieval scribes, who had often ruled their musical staff lines on the vellum in red ink, for its decorative effect as much as for any other reason. This printed staff gave the book a more satisfactory appearance, even though the regularity and artistic appearance of the printed page was likely to be disturbed by the irregularity of the manuscript musical note heads and stems.

There was one advantage in printing a staff without the notes. Liturgical usage in matters of music was not nearly as uniform

in the church of the fifteenth century as it is today. Even the words of the offices were not as uniformly fixed as they were later. Each larger ecclesiastical center or diocese had its own peculiar "use" for parts of the service. The monastic establishments departed from the official form to an even greater extent. In the matter of musical melodies, the special "uses" varied still more. In the interest of a wider sale some printers preferred to omit printed melodies from their publications. One difficulty with these printed books in which manuscript additions were made was that the paper chosen for its printing qualities, its proper reaction to printer's ink, did not always so readily take the ink used on a pen. This disadvantage, added to the irregularity of written notes, inevitably led craftsmen who looked to the artistic effect of their handiwork to seek a satisfactory method of complete music printing.

The difficulties of music-type printing were set forth in our discussion of the theory books. The liturgical printers, however, had an advantage over other book printers in that they had early resorted to the practice of producing a book by a double impression for the sake of two colors. They utilized this fact to secure a complete musical addition to their liturgical text. Once the problem of the long red lines of the printed staff were solved, it required only a little more ingenuity and accurate adjustment to utilize the black printing for placing note forms exactly where they belonged on the lines and spaces of the red staff. Whether the red lines were printed first and the black printing followed, or vice versa, was immaterial. The liturgical printers also had an advantage over other music printers in that the liturgical melodies were all comparatively simple as against the contrapuntal choral music. Liturgical music notation is not deeply concerned with the rhythmic problem, and by simplifying the style and the system of notation used in the liturgical manuscripts the printers were able to re-

duce the number of various type forms to two or three. At times they printed with only one form of note.

The first printer to use this method, as far as our present knowledge goes, was Ulrich Han or Hahn (Udalricus Gallus), whose *Missale secundum consuetudinem curie romane*, completed in Rome on October 12, 1476, was a double-process product, in which the difficult problem of adjusting the exact positions of the notes is solved in an eminently satisfactory fashion. Han uses five clearly printed red lines running across each of his double columns. His melodies are noted, to a very large extent, in the single-note form known as the *virga* (or *longa*), a square black head with a stem at the right side. His music pages have a clean, regular, and not unpleasing appearance.[22] There are columns or pages in which the musical notation occupies but a portion of the page, the rest being filled with ordinary letter text. There are also complete pages of music which seem to have been printed separately, in one fascicle, laid in the book at the proper place between the regular printed leaves, and bound in like an extra letter of the register. The practice of laying in the music as an extra gathering was often followed by those who printed music in missals after Han, and this may explain why even the more recent bibliographers of incunabula are strangely silent about the musical illustrations, though they describe minutely the type, the initials, the woodcuts, the illuminations, and the smallest details of the register.

The missal of 1476 seems to have been Han's only musical production. He had printed a missal in Rome in 1475, which had blank spaces for the music, and he died in 1478. It seems that the existence of music in Han's missal had never been made the subject of comment or study until it was "discovered" in 1901 by the Benedictine P. Raphael Molitor (9, pp. 94 ff.), and then made the subject of an article by Riemann (11) in the same year. Riemann (12), writing in 1896, and Barclay Squire (14), writing in 1897, are still concerned with establishing the priority

claims of printers who came after Han. And all this in spite of the fact that the colophon of Han's musical missal, as printed by Hain (No. 11366) in 1838, contained this passage: ". . . . non calamo. ereove stilo: sed novo artis ac solerti industrie genere Rome conflatum impressumque unacum cantu: quod nunquam factum extitit."

Whether earlier office books with type-printed music ever come to light or not, this book and those which immediately followed it seem to establish fairly clearly the fact that music printing with movable type actually antedated the musical block printing which was used in the theory books, beginning with Burtius in 1487.

As matters stand at present, Han's nearest successor was Leonard Pachel in Milan, who, according to Molitor (9, p. 101), printed a *Missale Ambrosianum* in 1478. He was followed by Octavianus Scotus of Monza, who printed in Venice, and Jörg Reyser, who printed in Würzburg. Scotus finished a Roman missal on December 29, 1481, and a Dominican missal on December 24, 1482. Both works are unusual in that their format is decidedly smaller than the usual office-book form. Their size is such that they might be conveniently held in the hand, although the celebrant of the mass cannot always hold a book. The music printing of Scotus presents an attractively clean and dainty appearance.[23] Scotus, like Han, used the square black note form known as "Roman notation." In the earlier of the two Scotus missals a music gathering marked *rr* is inserted between signatures *q* and *r* of the letter text.

Jörg Reyser's *Missale herbipolense* was printed in Würzburg in the same year as Scotus' Roman missal (1481). Reyser's book has no colophon, but it contains the privilege or patent granted to the printer by the Bishop of Würzburg. Now this privilege actually places a time limit upon the printing. It sets a date by which the work was to be completed, and this date is November 8, 1481. If Reyser lived up to his contract, his

book antedates Scotus' first music-book. Reyser's book contains twenty-one unnumbered pages of printed music, inserted between folios 110 and 111. It has a staff of four red lines running across the page. It seems to be the earliest-known musical office book that uses, not the square Roman notation found in the Italian works, but the peculiar angular and pointed Gothic note forms often called the "horseshoe-nail notation," which spread over all the northern countries after the thirteenth century.[24] This early book was followed by another Reyser musical office book within a few months, the *Agenda herbipolensis* (1482).[25]

From this time onward the number of missals and other liturgical books with music increases rapidly. They were printed by Stephan Planck in Rome, Georg Stuchs in Nuremberg, Johann Sensenschmidt with Johann Beckenhub in Bamberg, Johann Haman of Landau in Venice, and the firm of Michael Wenssler and Jacob de Kilchen in Basle. Many of their books are named or described by the authorities listed in our bibliography. We shall attempt to tabulate them briefly, but before presenting the list we shall offer a special comment on a small group of such incunabula in the possession of the Library of Congress in Washington. They were all printed in the last decade of the fifteenth century. Some of them have not yet been described by earlier writers.

The *Obsequiale ratisponense* printed in Nuremberg by G. Stuchs in 1491 has a staff of four red lines printed with rules. The rules were not always in one piece across the page. Joints are visible. The Gothic black notes are well adjusted on the lines. One hundred and eight pages contain music.

A *Missale romanum* printed in Venice by Johann Emerich of Speyer in 1493 is of interest because it resorts to the block-printing process. A staff of four black lines and square black notes are found on about forty-six pages, most of them full-page music printing.

A *Missale herbipolense* (Würzburg: Reyser, after October 1, 1493) contains thirty-six full pages of music. Four red lines are printed with rules that run across the whole page. The notes are in the Gothic style. In the same book the Good Friday office has blank spaces left for the music over the words *Oremus*, *Flectamus genu*, and *Levate*.

One of the most interesting items in the Washington collection is the *Processionarium ordinis praedicatorum* printed by Meynardus Ungut and Stanislaus Polonus in Seville in 1494. It is a fine specimen of clear printing with four red lines done by rule across the page and square black notes. The register is excellent. There is music on almost every page. Of the hundred and eighty-seven musical pages most are full-page music printing. Rafael Barris Muñoz (1) made the book the subject of a short essay in 1926, in which it is described as the first music-book printed in Spain. It is quite possible that it is the earliest Spanish type-printed music. But it is antedated by the music printed in Marcos Duran's *Lux bella* (Sevilla: Cuatro alemanes compañeros, 1492), which was mentioned in our discussion of the books on the theory of plainsong.[26]

Ratdolt's *Obsequiale brixinense* (Augsburg, *ca.* 1495) has four red lines printed, apparently with type, but the type blocks vary from about one-quarter of an inch in width to three inches or even more. The notes are black Gothic. The register is not as accurate as in most of the other musical books. There are about sixty pages of music.

The *Missale ordinis praedicatorum* printed in Venice in 1496 by Andreas Torresanus has four red lines in rules across each of the double columns and square black notes. About twenty pages show music.

Stephan Planck's *Liber pontificalis* (Rome, 1497) has five red lines running across each of the double columns with square black notes, mostly of the *virga* form. Music occurs on one hundred and seventy-nine pages.

A Salzburg *Missale* was printed in 1498 by Georg Stuchs in Nuremberg. The staff has each of its four lines printed with rule pieces of varying length. The black Gothic notes are almost all *puncta* (stemless black squares).

For the sake of comparison it might be mentioned that among the Washington incunabula a *Missale ordinis praedicatorum* printed by Antonius Zarotus in 1482 has blank spaces for manuscript music. Emerich von Speyer, whose block-printed music of the year 1493 has been cited above, produced a *Missale alme ecclesie strigonensis* in Venice in 1498, and in this book he prints a staff of four red lines with even type blocks about seven-eighths of an inch wide, leaving the notes to be supplied by hand. A *Missale insignis ecclesie leodiensis* printed in Paris by Johann Higman in 1499 has four red lines but no notes. The staff was printed with type about half an inch in width.

It will be observed in the list which follows that there are no specimens of actual music printing from France or from England. It is possible that a more careful search will disclose a French liturgical incunabulum with music which has hitherto escaped the notice of musical bibliographers. But we may be reasonably sure that no such work printed before 1500 is likely to come to light in England. Steele includes none in his essay on "The earliest English music printing." The *Missale ad usum Sarum* printed in Westminster in 1498 by Julian Notary and Jean Barbier for Wynkyn de Worde leaves blank spaces for the music. At least one of the Sarum missals printed in foreign countries contains music. It is the *Missale divinorum officiorum secundum usum ecclesiae Sarum anglicanae* printed in Venice in 1494 by Haman of Landau for Frederick Egmont. In all probability the demand for such books was not as great in France and England as it was in Italy and Germany.

Liturgical Incunabula with Printed Music

This list is by no means a complete bibliography. It is offered here as an aid to orientation in a field in which orientation

has hitherto been irritatingly difficult. I cannot even be sure of the accuracy of some of the entries. A number of them were drawn from dealers' catalogues and some from passing references in the works dealing with the subject. W. H. J. Weale's *Catalogus missalium ritus latini ab anno 1475* (London, 1856) will be of some aid in tracking down many of the works cited. Weale gives little information as to music, and Hain leaves us almost entirely in the lurch.

1476	Missale . . . . curie romane	Rome	U. Han (Gallus)
1478	Missale Ambrosianum	Milan	L. Pachel
1481	Missale . . . . romane ecclesie	Venice	O. Scotus
1481	Missale herbipolense	Würzburg	G. Reyser
1482	Ordo missalis . . . . romane curie	Venice	O. Scotus
1482	Missale . . . . fratrum praedicatorum	Venice	O. Scotus
1482	Missale moguntinensis	Würzburg	G. Reyser
1483 (*n.s.*)	Missale . . . . curie romane	Rome	S. Planck
1483 (*ca.*)	Missale . . . . cenobii melicensis	Nuremberg	G. Stuchs
1484	Missale herbipolense	Würzburg	G. Reyser
1485	Liber missalis . . . . ecclesie ratisponensis	Regensburg	J. Sensenschmidt & J. Beckenhaub
1487	Missale . . . . ecclesie frisingensis	Bamberg	J. Sensenschmidt
1487	Obsequiale augustense	Augsburg	E. Ratdolt
1488	Missale . . . . romane ecclesie	Venice	J. Hamann
1488	Liber missalis . . . . olomucensis	Bamberg	J. Sensenschmidt
1488	Graduale basileense*	Basle	M. Wenssler & J. de Kilchen
1488	Agenda parochialium ecclesiarum†	Basle	Wenssler & Kilchen
1490	Missale . . . . ecclesie bambergensis	Bamberg	J. Sensenschmidt & H. Petzensteiner
1491	Liber missalis . . . . augustensis	Augsburg	E. Ratdolt
1491	Agenda sive obsequiale . . . . bambergensis	Bamberg	L. Sensenschmidt, Pfeyl & Petzensteiner
1491	Obsequiale ratisponense	Nuremberg	G. Stuchs
1492	Missale . . . . ecclesie saltzpurgensis	Nuremberg	G. Stuchs
1492	Liber missalis . . . . ecclesie ratisponensis	Bamberg	H. Pfeyl & H. Petzensteiner
1493	Missale . . . . ecclesie romane	Venice	J. Hertzog de Landoia *for* O. Scotus
1493	Missale herbipolense	Würzburg	G. Reyser
1493	Missale . . . . curie romane	Venice	J. Emerich

* A facsimile is in Squire (14, p. 111).

† A facsimile, all black, is in Weale, *A descriptive catalog*, p. 67. See note 19.

1493	Missale .... romane ecclesie	Venice	J. Hamann (Hertzog) *for* Nicolaus de Franckfordia
1494	Missale .... ecclesie Sarum anglicane	Venice	J. Hamann *for* F. Egmont
1494	Processionarium ordinis praedicatorum	Seville	M. Ungut & Stanislaus Polonus
1494	Processionarium fratrum praedicatorum	Venice	J. Emerich *for* Lucantonio Giunta
1495 (*ca.*)	Obsequiale brixinense	Augsburg	E. Ratdolt
1496	Missale ordinis praedicatorum	Venice	A. Torresanus
1497	Missale	Paris	U. Gering & B. Rembolt
1497	Missale curiense	Augsburg	E. Ratdolt
1497	Liber pontificalis	Rome	S. Planck
1498	Missale salisburgense	Nuremberg	G. Stuchs
1499	Missale babenbergense	Bamberg	J. Pfeyl

In connection with the works listed above it should be remembered that they are almost all double-process products. The lines and the notes were done by separate impressions. It is interesting to observe that while some printers preferred to print the staff with rules that ran straight across the page or the column, others experimented with type for the staff also. They produced their staff in segments, more or less skilfully joined. The type segments varied in length from about one-quarter of an inch to about one inch in width, although in Ratdolt's *Obsequiale brixinense* (Augsburg, *ca.* 1495) we seem to run across type blocks as long as three inches. The number of plainsong note forms varies from one to four. There are plainsong books in which the note heads alone are printed without stems (Sensenschmidt, Petri, Stuchs, Pforzheim), which, as Riemann (10, p. 680) remarks, give the page a less satisfactory, uneasy appearance, less helpful to the eye in reading. The Wenssler and Kilchen *Gradual* (1488) uses four plainsong note forms and in addition borrows from the mensural note forms the stemmed lozenge, the *minima*.[27]

This, then, was the style of musical-type printing which was in use during the last quarter of the fifteenth century. With the

exception of such incomplete experiments as we found in Francesco Niger's *Grammatica brevis*, it was restricted entirely to liturgical books, that is, to plainsong music.

It remained for Ottaviano dei Petrucci da Fossombrone to solve the problem of applying the process to the more complicated and hence more difficult task of printing mensural music, and thus opening up to the printing industry the ever expanding field of polyphonic choral music, and especially the field of secular music. Petrucci solved his problem with such brilliant éclat that for many years he was regarded as the actual inventor of the art of printing music with movable type.[28] The comparatively recent study of the printed plainsong books has deprived him of that proud title. As early as 1868 Fetis (*Biographie universelle des musiciens*, 2d ed.) remarked that plainsong printing with movable type had been accomplished before Petrucci's time. But the Italian's merits, even thus, are so noteworthy that he will probably remain the greatest figure in the history of music printing.

Petrucci's patent or privilege for "the printing of mensural music with movable type" was granted him on May 25, 1498, by the Signory of Venice for a period of twenty years. The first known work from his press did not appear until 1501. It was entitled *Harmonice musices Odhecaton A*. The book did not contain, as the title might lead us to suppose, one hundred pieces, but ninety-six: forty-nine compositions for three voices and forty-seven for four. By far the greater number of the compositions are French *chansons*, but in this publication the words of the songs are not printed in full as in later books. Only the initial words of each song are given. The famous composers of the day, Okeghem Obrecht, Compere, Tinctoris, Pierre de la Rue, Agricola, Isaac, Josquin, Busnois, Brumel, and others are included. More than fifty later publications are credited to Petrucci.

Petrucci's method was, like that of the plainsong printers, a

double process. The staff in black, as in ordinary music-books, was done in one impression, the notes in another. It has been suggested that in some of his books he resorted to a third impression for the words of the text. But this seems uncertain. In fact, Petrucci's whole procedure seems to have remained something of a mystery up to the present day. It seems almost incredible that at that early period, with only the experience of the plainsong printers to profit by, any craftsman should have been able to arrive at the precision of adjustment which characterizes Petrucci's presswork. The accuracy of the position of the notes on the lines and in the spaces leaves nothing to be desired. And this printer's books were much smaller than the office books of the church. They were meant to be held in the hand of the singer. The notes and the staff are as small or smaller than in the ordinary sheet music of the present day.

Added to the accuracy of the register we find a clear-cut type; graceful, dainty, well-spaced note forms; evenness of inking; cleanliness of impression; excellent paper—in a word, masterpieces of the printer's art. The astounding perfection of Petrucci's craft was soon lost by his immediate successors, and not equaled for centuries.

But Petrucci's printing must have been a rather expensive operation. The practical utility of music printing could not be assured until the double process was replaced by a single operation. The first reasonably successful attempts in this direction were made in France by Pierre Haultin (or Hautin). Fournier (4) assigns Hautin's invention to the year 1525. Hautin was a type-cutter and a printer. His type seems to have been first used by the Paris music printer and publisher, Pierre Attaingnant, from whose press no work dated earlier than 1528 is now known. Hautin's dies were, for the most part, narrow vertical segments of the staff with the note head and the proper stem cut right on the body with the five-staff lines. At times, however, Hautin broke his vertical segments into several parts,

so that it was possible for him to set up such a segment including several note heads in a vertical arrangement, thus enabling him to print, not a single line of notes as sung in a vocal part, but whole chords as played by the right and the left hand on a keyboard instrument. This process was used in 1530 by Attaingnant in his collection, *Dix neuf chansons en tablature des orgues, espinettes, manicordions* and in later collections.[29]

The music of the present day is largely printed from engraved plates by the offset process. But for books which contain much letter text, like popular songbooks or hymnbooks, a very complicated method of type composition is still used. The interposition of a stereotype process between the type form and the printed sheet makes it possible to remove all traces of type and line junctions, so that these books have the even, continuous appearance of engraved music.

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13. ———. "Zur Musiktypographie in der Inkunabelzeit," *Beiträge zur Bücherkunde und Philologie August Wilmanns . . . . gewidmet* (Leipzig, 1903), pp. 173–80.

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15. Steele, Robert. *The earliest English music printing.* London, 1903. ("Bibliographical Society illustrated monographs," No. 11.)

16. ———. "What fifteenth century books are about." *Library* (London, 1903–7), N.S., IV, 337–54; V, 337–58; VI, 137–55; VIII, 225–38.

17. Vogel, Emil. "Der erste mit beweglichen Metalltypen hergestellte Notendruck für Figuralmusik," *Jahrbuch der Musikbibliothek Peters für 1895*, pp. 47–60.

18. Wendel, Carl. "Aus der Wiegenzeit des Notendruckes," *Centralblatt für Bibliothekswesen* (Leipzig, 1902), XIX, 569–81.

An excellent survey of the literature on the subject up to the year 1902.

Notes

1. The figures in parentheses refer to the bibliography given on pp. 115–16.

2. My thanks are due to my friend and colleague, Mr. Victor H. Paltsits, for having brought this interesting study to my notice.

3. The early Strasburg *Etymologies* of Isidor, a Lyons, 1482, edition of *De proprietatibus rerum*, as well as a Modena, 1500, edition of the *Opera* of Martianus Capella, were

shown in the exhibition arranged by the Newberry Library for the 1930 midwinter meeting of the Bibliographical Society of America.

4. A copy of Boethius' *Opera* (Venice, 1497) was shown in the Newberry Library exhibit.

5. Extracts from both works and commentary by Martin Vogeleis are in *Monatshefte für Musikgeschichte*, XX, 41, 95, and 152.

6. The work of Ramis is easily accessible in the modern edition of Johannes Wolf (*Publikationen der Internationalen Musikgesellschaft* [Leipzig, 1901], Beihefte II), which contains, in an Appendix, copious extracts from the opponents of Ramis. See also the excellent bibliographical study by Albano Sorbelli, "Le due edizioni della *Musica practica* di Bartolomé Ramis de Pareja," *Gutenberg Jahrbuch*, 1930, pp. 104–14. The printer has been identified as Baldassare Strucci da Rubiera.

7. A copy was shown in the Newberry Library exhibition.

8. A facsimile is in Georg Kinsky, *Geschichte der Musik in Bildern* (Eng. ed. under the title, *A History of music in pictures*), p. 61.

9. See Haebler, *Bibliografía ibérica del siglo XV* (Leipzig, 1903), [I], 108–9.

10. Tinctoris' dictionary remained practically unknown until the time of Padre Martini, Burney, and Forkel. The last-named author reprinted the whole dictionary in his *Allgemeine Litteratur der Musik* (Leipzig, 1792), pp. 204–16. According to Riemann (*Musiklexikon*, 11th ed.), it was reprinted again, edited by Bishop, as a supplement to the second edition of James Alexander Hamilton's *New theoretical musical grammar*. I have not been able to locate a copy of such an edition. The *Catalogue of the London Library: Supplement, 1920–1928*, p. 413, contains this entry under Hamilton: "Dict.; explan. of 3500 Ital., French, German, Eng. &c musical terms &c. With reprint of John Tinctor's 'Terminorum music. diffinitorium.' Ed. J. Bishop. [47th ed.] n.d." Coussemaker reproduces it in the fourth volume of his *Scriptores* (Paris, 1876), and finally the whole Latin text with a German translation by Heinrich Bellerman was published in Chrysander's *Jahrbuch für die musikalische Wissenschaft*, I (1863), 55–114.

11. For a facsimile and a translation by G. F. Barwick of the passage of Gerson's text see Littleton (6, pp. 5–6); another facsimile is in Riemann (10, Tafel 8) and Steele (15, Fig. 1); also in Kinsky, *op. cit.* (also in the Eng. ed.), p. 61. A copy of the original in the Library of Congress has no lines.

12. This edition and an edition printed in Basle in 1485 are in the Library of Congress.

13. A facsimile of a page from Niger's grammar is in Littleton (6, p. 15). According to Littleton, a Basle, 1500, edition of this work has the staff printed.

14. A facsimile is in Steele (15, Fig. 1) and Littleton (6, p. 26). A copy of the original was shown in the Newberry Library exhibit.

15. On the question of the use of metal-block printing for music see Riemann (10, pp. 45–46 and Tafel 11).

16. A facsimile of the hymn is given by Barclay Squire (14, p. 114); by Steele (15, Fig. 3); and by Kinsky, *op. cit.* (also in the Eng. ed.), p. 61. The contrapuntal piece from Part II has often been reproduced in facsimile. See Grove's *Dictionary*, *s.v.* "Printing of music," and Littleton (6, p. 17). T. F. Dibdin in his *Bibliotheca Spenceriana*, III, 233–36, devotes four pages to a description of this book. He reproduces in facsimile the *tenor* and *contra* of the mensural piece and the cut from Part III, illustrating ligatures.

17. A modern edition by Carl Beck, with the music transcribed into modern notation, may be found in the *Bibliothek des Litterarischen Vereins in Stuttgart* (Stuttgart, 1868), Vol. LXXXIX.

18. A facsimile of wood-block music from a Keinspeck *Lilium* printed in Ulm by Johann Schäffler in 1497 is in Molitor (8, p. 7).

19. See W. H. J. Weale, *A descriptive catalogue of rare manuscripts and printed works, chiefly liturgical* (Historical Music Loan Exhibition, Albert Hall, London, January–October, 1885; London, 1886), p. 176; also Riemann (10, p. 42) and Littleton (6, p. 18).

20. A leaf of this Psalter with manuscript music was included in the Newberry Library exhibition. A handsome colored facsimile, likewise with music, from the 1459 edition may be seen in the *Catalogue of manuscripts and early printed books . . . . Library of J. Pierpont Morgan*, I, opp. 10.

21. On Schoeffer as a music printer see Springer (13, p. 177).

22. A copy of this missal was displayed in the Newberry Library exhibition. A facsimile is in Molitor (8, Tafel 1).

23. A facsimile from the Dominican missal is in Riemann (10, Tafel 14).

24. A facsimile is in Riemann (10, Tafel 17). Two facsimiles from different editions of the same missal are in Molitor (8, Tafeln 3 and 4). See also G. Kinsky, *op. cit.* (likewise in the Eng. ed.), p. 61.

25. For comments on this and several other Reyser music-books not known to earlier bibliographers see Springer (13, pp. 174–75). A facsimile in black only is in *Veröffentlichungen der Gesellschaft für Typenkunde*, Tafel 1141. Another slightly different facsimile in two colors is in Joseph Baer & Co.'s *Antiquariatskatalog 769* (Frankfurt-am-Main, 1930), opp. p. 64, item 911.

26. My attention was first drawn to this by a note penciled inside the cover of the copy in the Music Division of the Library of Congress quoting a passage from Konrad Haebler's *Geschichte des spanischen Frühdrucks* (1923), p. 364, in which Duran's work is cited as probably the oldest book containing Spanish music printing. For details on *Lux bella* see p. 96 of this article.

27. On the use of mensural notation in manuscript plainsong books see Springer (13, pp. 176–77).

28. The earliest books on Petrucci were Anton Schmid, *Ottaviano dei Petrucci da Fossombrone, der erste Erfinder des Musiknotendruckes mit beweglichen Metalltypen* (Wien, 1845); Augusto Vernarecci, *Ottaviano de' Petrucci, inventore dei tipi mobili metallici fusi della musica* (Fossombrone, 1881; 2d ed., with unchanged title, Bologna, 1882).

29. A facsimile of two pages of the vocal music is in H. Expert, *Les maitres musiciens de la renaissance française* (Paris, 1897), [Vol. V]. Facsimiles of complete Attaingnant booklets with organ music have been edited by E. Bernoulli (München, 1914) and by Yvonne Rokseth (Paris, 1925).

MINERAL TECHNOLOGY: FIFTEENTH CENTURY

By Thomas T. Read

MY TASK, as I understand it, is to express to you a concise appraisal of the value, from the standpoint of mineral technology, of the flood of literature released in the fifteenth century by the breaking of the dam of cost of reproduction of texts through the introduction into the Western world of the art of printing. The temptation is strong to follow the method of the chairman, in the threadbare story, who said there would be no discussion of the best method to shelve atlases, because there is no good way. Using a similarly sweeping and inaccurate generalization, I might say that the books of the fifteenth century are of no value from the standpoint of mineral technology. That would, of course, not be true; because they were all the books that existed before the sixteenth century and any kind of a book is better than none. And though (contrary to popular belief) the ancients knew no "secrets" of technical procedure that we are ignorant of today, while their faulty concepts of the nature and constitution of natural substances and the totally different circumstances under which they worked make their accounts of mineral technology of little or no practical value to us today, they are of much historical interest. Indeed, they deserve much more careful study than they have received from technologists, who should be able to help correct the many, and oftentimes egregious, blunders that have been made in translation, and so provide for the students of social conditions in ancient times a more accurate picture of them than they now possess.

Why the modern mineral technologist finds the ancient literature of but little practical help to him is worth discussing in more detail. In the first place, as you well know, the useful arts were not considered in those days as proper objects of scholarly study. In addition, the metallurgical art was to a considerable degree made up of "trade secrets" of procedure and acquired skill that were imparted only to the children or apprentices of the artisans, most of whom were probably unable either to read or to write. To the inquirer into their affairs they undoubtedly imparted the mixture of vague general information and detailed misinformation that we find preserved for us in the writing of the ancient travelers and encyclopedists.

The concluding words of the paragraph above reveal another of the drawbacks of this early literature; broadly speaking, it was composed by reporters who had little or no first-hand knowledge of what they were reporting. The inevitable consequences of this have been recently illustrated by the perusal of an English translation of a German monograph on the technical arts and sciences of the ancients. The translator is apparently not very familiar with the vocabulary of technology and so uses the wrong English words (such as referring to the "peak" of a casting when the right word is "fin"), somewhat to the confusion of the reader. But beyond that two other difficulties lie. Not only is it impossible for a man who attempts to cover the whole field of technology, from iron-smelting to brewing and paper-making, to have a thorough knowledge of all these subjects (with the result that he describes things the way he thought they must be rather than the way they actually were), but also he describes them in language that even in the original would be a little difficult for a technologist to follow and when translated (as it has to be for most technologists) is perhaps impossible. Slight differences are often quite baffling. The other day a friend called on a business man of the city, a Frenchman, who talked to him about a "ma-nag'-er"; it was several minutes before my

friend was able, even with the aid of the remainder of the speech, to pierce through the slight mispronunciation and understand the word.

Very few technologists, unfortunately, are able to read the fifteenth-century books in the original. What I have said will indicate why they are not much interested in translations of them; but perhaps I should say more as to why they are not sufficiently interested in them to submit themselves to the linguistic discipline necessary to enable them to read the original.

Pliny's *Natural history*[1] is, from the standpoint of mineral technology, the most notable fifteenth-century book. Pliny was, as you are well aware, a traveler who having seen a great many things committed them to writing, presumably to make them available to a larger audience and to save himself the labor of repeating himself (which must have been something of a bore); possibly he was quite unaware that the physical achievement of writing was the essential thing in making him one of the immortals. It is reasonable to suppose (indeed, his text indicates it) that there were many contemporary people who knew more about such things than he did. It is also reasonable to suppose that having written down what he had seen he was soon led into adding to it what he had merely heard and then to reproducing (without credit)[2] what others had previously written. He was obviously indebted to Theophrastus and Dioscorides, who both accepted Aristotle's fantastically wrong theory of all natural substances being composed of earth, water, air, and fire, and in the portions of his last four books (the only ones that deal with mineral technology, and these only in part) he adds but few minerals to the list given by his Greek contemporary and his predecessor. What he says on metallurgical subjects is so obscure that until last year, when Kenneth C. Bailey[3] translated and edited his text from the standpoint of the chemist, naturally including metallurgy, no fully competent translator had essayed the task of elucidating it in any language.

The only work of Theophrastus[4] published in the fifteenth century was that *On stones;* his text on mining and metallurgy was already lost. He describes some sixteen mineral species, the making of white lead, and the production of quicksilver from its ore, cinnabar. He does not completely accept Aristotle's theories about the elements, and altogether he gives us the most authentic picture of the mineralogical knowledge of his day that we have. Diodorus'[5] much more voluminous text, printed in the fifteenth century, deals but little with mineral technology, and his most valuable feature is the quotation from Agatharchides on Egyptian gold-mining. This is not only the first text we have on that subject, but also the first on the crushing and concentration of ores, and it is at least the clearest if not perhaps the first early description of vein-mining. Diodorus also mentions the mining of tin in Britain and Spain; he is much more clear on this than Pliny, who thinks tin to be merely a variant form of lead.

Dioscorides[6] is of much interest to the student of mineral substances because of his extensive remarks on them from the viewpoint *of materia medica*, and he adds a great deal to the earlier writings by describing previously unmentioned minerals and the preparation of useful products from them.

Vitruvius,[7] a contemporary of Pliny to whom the latter apparently owes much, was an architect, and his writings in the field assigned to me are naturally limited to building stones and the preparation of pigments for painting; probably he had a more personal knowledge of them than an architect of today would have. His story[8] of how Archimedes discovered specific gravity to solve the problem of determining how much silver there was in Hiero's gold crown will serve to illustrate how later commentators drew false conclusions from such evidence. Meyer[9] in his history of chemistry supposes that this story proves that the ancients did not know how to separate gold from silver; apparently it never occurs to him that a condition of the problem was to solve it without marring the crown.

Another example of this failing of commentators may be added. Neuburger[10] in his *Die Technik des Alterthums* (Brose's trans., p. 42) refers to the employment of an unusual alloy of tin and copper for making coin dies in Egypt previous to the fourth century B.C. and, noting that it was especially well suited to this purpose, says it "shows how clearly the influence of chemical composition on physical properties was recognized even at that time." Of course it shows nothing of the sort, as a personal experience will illustrate.

During 1909, while traveling in Western China, I found the native metallurgists casting iron teapots of remarkable thinness and fidelity of outline. They explained that they were able to do this because they added to a pot of metal a handful of material which they called "black earth"; the composition of this was entirely unknown to them. Microscopic and chemical examination revealed that it was largely composed of the phosphorus mineral vivianite, and the phosphorus, entering the metal, rendered it fluid and capable of being made into a thin casting. They did not know, however, that there was any phosphorus in the "black earth," or even that there is such a thing as phosphorus; all they knew was that if they added the right amount of "black earth" they got good castings.

It might be further pointed out that the die described by Neuberger not only does not prove that the Egyptians understood the influence of chemical composition on properties, but it does not even prove, as he unquestionably assumes, that coins were being struck in Egypt by that date, for it is a die of a Greek coin, and it seems at least as probable that it was carried to Egypt as that the Egyptians were making Greek coins.

I should like to speak of Theophilus Rugerus and his treatment of the materials of ecclesiastical construction in the eleventh century as well as his comments on the metallurgy of his period in his comprehensive study of the making of bells, chalices, etc., but must pass him by because he did not appear in

print until a later date. Geber (whether one Arabic scholar or merely a convenient way of citing several whose works have been thrown together)[11] brings us into the heart of the alchemist period, when the unsound idea that all things were made out of earth, air, water, and fire ripened into the inference that gold and other metals could perhaps be produced in laboratories. In the works attributed to him we first find the making of acids and the preparation of salts from them clearly described. His theory that all metals were composed of varying proportions of quicksilver and of spiritual sulphur (arsenic) dominated metallurgical thought for centuries, and in a world in which it was not yet customary to check up the pronouncements of authorities it was perhaps unfortunate that they were published. The unsound idea that gold was a compound and could therefore be produced from other substances if the way were only learned led to centuries of wasted effort, for though it was productive of much experimental work it gave a wrong objective.

Possibly the early incorrect theories could have been controverted in no other way than that which was followed, and the phrase "transmutation of metals" that is commonly employed does some at least of those early workers something of an injustice by conveying the inference that they hoped to transmute one element into another. They knew that by fusing soda and sand, for example, they were able to make something quite unlike either, and they were unaware that there was a fundamental difference between glass and gold in that glass is a compound while gold is an element. The qualities they valued in gold were its color and resistance to corrosion, and if they had been able to make an alloy that had the same qualities it would have been, from their viewpoint, gold. Their labors had a wrong but not a foolish objective; it was through belief in the magic of a philosopher's stone that it degenerated into charlatanism.

Albertus Magnus,[12] reputed to be the most learned man of his time, included mineral technology in his literary productions.

Part at least of the works attributed to him are probably spurious, but three of them dealing with minerals are considered genuine. Except for writings that concern themselves with gems, his text on minerals is the only one of much importance that appeared between Pliny's work and the sixteenth century, when Agricola (George Bauer) began to write on the subject from sound personal knowledge. Albertus adds only two or three minerals, however, to the lists of Theophrastus, Dioscorides, and Pliny. The rest of his work seems to be chiefly an attempt to reconcile the discrepancies in earlier writings and the result is a mélange of the classics with Arabic natural science that is of little value to the mineral technologist even as a record of the knowledge of the period.

Vincent of Beauvais[13] was an encyclopedist and his works attract, and seem to merit, but little attention today. Many authors whose principal interest was chemistry are not mentioned here. Nor have I attempted any evaluation of the Latin translations of various Arabic texts dealing, to some degree at least, with mineral technology that appeared in the fifteenth century, and which are listed in Sarton's[14] painstaking monograph on the history of science, for I have no personal knowledge of them and know of no one in my field of work who has. Whether they would repay the time required for critical study of them is at least open to doubt.

It is not easy, therefore, to be certain of one's judgment in attempting an evaluation of the books of the fifteenth century. One of the few points on which one can be certain is that they have not even yet been the object of sufficient critical study by scholars whose technical knowledge of the matters discussed is sufficient to extract their full content and to refrain from imputing to them concepts that they do not possess. Fortunately there seem to be signs of an increasing interest in the historical phases of mineral technology and perhaps that condition, which has so long persisted, will eventually be remedied.

Notes

1. Hain lists eighteen Latin and three Italian texts between 1468 and 1499.

2. In some cases he uses the exact words of Vitruvius.

3. *The elder Pliny's chapters on chemical subjects*, Part I. Ed., with translations and notes, by Kenneth C. Bailey. London: Edward Arnold & Co., 1929. 8°.

4. *De historia et causis plantarum*, lat. Theodoro Gaza interprete. Tarvisii: Bartholomaeus Confalonerius de Salodio, 1483. (Hain 15491.)

5. Diodorus Siculus, *Bibliotheca seu historiarum priscarum*, lib. VI, e graeco in latinum traducti per Fr. Poggium.

Bononiae. (Ugo Rugerius et Dom. Bertochus), 1472. (Hain 6188.)

———. Venetiis: Andreas (de Paltascichis), 1476. (Hain 6189.)

———. Venetiis: Thomas de Blauis Alexandrinus, 1481, (Hain 6190).

———. Venetiis: Ioannes de Cereto de Tridino alias Tacuinus, 1496. (Hain 6191.)

———. Paris: Petit, s.a. (Copinger 1981.)

6. *De materia medica.* Venetiis: Aldus, 1499. (Hain 6257.)

———. Colle: Johannes de Medemblick, 1478. (Hain 6258.)

7. *De architectura.* Roma: Georgius Herolt, 1486. (Copinger 6268.)

———. Florentiae, Venetiis, 1496[–95]. (Proctor 6403.)

8. L. 9, praef. 9–12.

9. Ernst von Meyer, *Geschichte der Chemie von den ältesten Zeiten bis zur Gegenwart.* Zugleich Einführung in das Studium der Chemie. Leipzig: Veit & Co., 1889. 8°.

———. Zweite verbesserte und vermehrte Auflage. Leipzig: Veit & Co., 1895. 8°.

———. Dritte verbesserte und vermehrte Auflage. Leipzig: Veit & Co., 1905. 8°.

———. Vierte verbesserte und vermehrte Auflage. Leipzig: Veit & Co., 1914. 8°.

———. *A history of chemistry from earliest times to the present day; being also an introduction to the study of the science. . . .* Translated with the author's sanction by George McGowan. London: Macmillan, 1891. 8°.

———. 2d English ed., translated from 2d German ed. with numerous additions and alterations. London: Macmillan, 1898. 8°.

———. 3d English ed., translated from 3d German ed. with various additions and alterations. London: Macmillan, 1906. 8°.

10. Albert Neuberger, *Die Technik des Altertums*, p. 45. Leipzig: Voigtländer, 1919. 8°.

———. *The technical arts and sciences of the ancients*, trans. by Henry L. Brose, p. 42. New York: Macmillan, 1930.

11. *Liber qui "Flos naturarum" vocatur*, s.l., 1473. (Hain 7504.)

12. Hain's numbers run from 427 to 572, which gives an idea of the man's popularity at that time.

Mineralium, lib. V, s.l.a. et typ. n. 521.

———. Padua: Maufer, 1476. 520.

(Huntington Library has the only copy in this country.)

———. Papie: Christopher de Canibus, 1491. 521.

(Library of Congress has a copy.)

———. Venetiis: Ioannes Gregorius, 1485. 522.
(Harvard has a copy.)

13. Vincentius Bellovacensis.
Speculum historiale. Strassburg: Johann Mentelin, 1473. 2 vols.
Speculum morale. Strassburg: Mentelin, 1476.
Speculum doctrinale. Strassburg: Adolf Rusch, 1480.
Speculum naturale. Strassburg: Rusch, *ca.* 1480. 2 vols.

14. George Sarton, *Introduction to the History of Science,* Vol. I (to end of eleventh century). Baltimore: Williams & Wilkins Co., 1927.

BIBLIOGRAPHY AND LEGAL HISTORY

By Theodore F. T. Plucknett

NO LAWYER in this country can think of the printing press without feelings of deep concern. If he remembers Bracton's old boast that the law of England is unwritten, he will add that at any rate it is very much printed in these latter days, and will point to the thousands of costly volumes which constitute his professional literature. If he is also a legal historian, he may speculate for a moment whether it might not have been better if English law had been written in the thirteenth century, for those legal systems which were "written"—that is to say, based upon the written *Corpus juris civilis* of Justinian—seem able to work at the present day with a mere handful of volumes compared with the enormous collections which are in daily use by practitioners of the common law. But even while these thoughts flit through his mind, the presses are pouring out fresh statutes, new reports, more recent annotations, and the morning's mail will bring advance sheets and loose leaves—for we cannot wait for complete volumes—indexed and numbered with curious ciphers devised by law publishers who thus teach their victims to bear ever increasing burdens. It is a far call from Gutenberg to the West Publishing Company and its fellow-producers of legal material, but history is indivisible, and a history of lawbook printing would be unworthy of the name unless it told the whole story, rising to the climax in our own day when the legal profession is overwhelmed by the products of the press.

The books which are in constant use cannot fail to influence

the mental habits of their readers, and so it must be evident that the legal mind, and consequently the law itself, will bear the marks of the tools which fashioned them. The printing press, in fact, has forced our law into a peculiar mold, and a special type of legal thought has been created by the system of law publishing upon which lawyers depend.

We have here a question of profound importance, whose treatment demands a study of bibliography in its most general aspects. The bibliographer must not confine his attention to xylography, paper, and parchment; the modern equivalents may be less beautiful but they are immeasurably more powerful, and if for that reason alone, we must speak respectfully of linotype, monotype, and woodpulp. When bibliography has caught up with the modern printing press it will surely make some illuminating contributions to the history of society, and especially of the common law.

The press is today one of the major factors in legal development. Has it always been so? Admitting that the nineteenth century saw an immensely rapid development in the technique of commercial printing and in the enterprise of powerful publishing houses, nevertheless may we not look to earlier centuries for the first indications of the influence of the press upon the legal profession? May we not find there some secret reason for the peculiar susceptibility of the law to the influence of the press? Moreover, what light does a study of early printed lawbooks throw upon the attitude of the profession toward the tools with which it worked? What were those tools, and how did they influence the growth of the law?

These are matters of importance for the legal historian and the answer to them lies in the scientific study of bibliography. But it must be admitted at once that the answer has not yet been given. The necessary combination of legal and bibliographical learning is rare, and even when it exists it may not necessarily direct its possessor to this particular line of investi-

gation. For example, W. A. Copinger, LL.D., barrister-at-law, and professor of law in Victoria University, might well have undertaken it, but unfortunately his interests were scattered in such diverse quarters as the bibliography of the Bible and Virgil, and the profundities of predestination; consequently it seems never to have occurred to him, eminent conveyancer and historian as he was, to study early lawbooks from this point of view. The same seems to be generally true of all bibliographers with but few exceptions. As Mr. Seymour de Ricci has pointed out,[1] the only detailed studies of lawbooks as a class apart are to be found in Italy, where the large mass of *Statuti* has been made the subject of studies from several learned hands,[2] and in England, where English lawbooks, and especially the *Year books*, have been collected by an amateur who had serious claims to distinction as an astronomer, but was never professionally connected with the law.[3] Outside of these two special fields the investigator of early legal literature will find little guidance.[4] He is best provided for in the study of canon law, for the early prints are listed by Schulte as part of his description of the medieval authorities on the subject.[5] For Roman law there is no general work later than Savigny covering the whole field, and as this monumental book is nearly a century old, it is not abreast of modern bibliographical research.[6] For the national laws there are only incidental discussions of early printed editions in the various histories.[7] Naturally, historians are most concerned with the modern critical texts which supersede the old prints; although it must be remembered that in some cases, especially in canon law, the fifteenth-century prints are still the only ones available even in these days when texts are re-edited with such zeal. For all these fields there is therefore only one course, and that is a systematic listing and study of the earliest Continental lawbooks with special reference to their provenance, their text, their printers and promoters, and the indications of their use and popularity. In the course of

such a study it is very probable that bibliography as well as legal history would be enriched by an accession of much new detail and greater precision.

It is obviously beyond the scope of this paper to undertake so vast a task, and so we shall devote the remainder of it to a consideration of the English legal literature which was put into print during the fifteenth century, with indications of its bearings upon our legal history.

Perhaps we may best begin with the books which were not produced, by way of introduction to those which were. There is surely a meaning in the fact that not a single complete edition of the *Corpus juris civilis* or of the *Corpus juris canonici* has yet been produced in England. The fifteenth-century editions of both these great texts are numerous. It must be admitted that their production was an enormous undertaking requiring considerable capital and mechanical resources, and that the complicated arrangement of text and encircling gloss made heavy demands upon the technical skill of the printer. Still, our English printers overcame such difficulties in five editions of Lyndewode between 1483(?) and 1499, and eleven more were to follow by 1557.[8] But although the papal books were not printed in England, the numerous editions of Lyndewode show that canon law was actively studied throughout the reigns of Henry VII and Henry VIII in spite of the religious and political upheaval. Indeed, it is only in the last three editions that political influences can be traced. All the editions down to 1529, the year of the Reformation Parliament, are in Latin; but by 1534 much had happened, and the act of supremacy passed in that year coincides exactly with the appearance of Lyndewode in English —for the only time. In 1557 it is again printed in Latin, and for the obvious reason of the Catholic reaction under Mary. No other edition came out until the last, in 1679, and this was the year of the defeat of the Exclusion Bill. The fluctuations in the fortunes of canon law are therefore easily traceable in the edi-

tions of Lyndewode, and the complete absence of any edition of the papal *corpus* may be perhaps sufficiently explained by the number of the Continental editions which must have been sufficient to meet the demand. As for the *Corpus juris civilis*, one would expect some trace of it in England, for its study was nominally required in the universities; but it seems that our really ambitious civilians went abroad for their training, and no doubt bought their copies on the Continent.

Besides Lyndewode, there are two types of canonical material issued from English presses during the fifteenth century, both of them historically significant from the lack of secular counterparts. First, there were the indulgences. Great as their part was to be in the theological controversies of the time, one may venture the suggestion that they have another and equally far-reaching importance, for they seem to be the first examples of the use of printed forms with blank spaces to be filled in by hand. It is characteristic that the church should have thus discovered the administrative possibilities of the press, for she had long been regarded as a model of business management. Today it is obvious that our complicated machinery of state would cease to work if the supply of printed forms were suddenly to cease. The history of this device might well attract bibliographers; at present very little is known of it, and the field is certainly not exhausted by collectors. At present it would seem that the indulgence is the first example of the printed form, and that thence it spread to diocesan offices where it was used in local ecclesiastical administration, and finally to the public services where its use remained for a long time rare. Occasional examples come from the sixteenth century, and mainly from the second half of it, and are not really numerous even in the seventeenth century.[9]

It took us a long time to learn the art of government by printed form, but an easier lesson was that of government by proclamation, and here too the church was perhaps our teacher.

We have a few printed copies of bulls from English presses of the fifteenth century, and they are followed first by a proclamation of Henry VII calling attention to a papal bull in his favor, and then by a series beginning in 1505 which quickly swelled to tremendous proportions. Over five hundred appeared in the sixteenth century, and nine hundred in the next forty years. There is no need to comment on the constitutional importance of this attempt at government by proclamation.

So much, then, for the canonical products of the English press and their consequences. When we come to the English common law, we must note the significant absence of an edition of Bracton, "the flower and crown of English jurisprudence." Written in the middle of the thirteenth century, Bracton's book is the only treatment of English law on a large scale until the *Commentaries* of Blackstone. Manuscripts are numerous, and the subject matter was by no means obsolete in 1500.[10] The apparent absence of a demand for Bracton's treatise can only be explained by an examination of the lawbooks which our early printers judged more appropriate for their public. As we shall see, they were of a peculiar character and represented a point of view which differed widely from that of the scholarly and philosophical jurist of Henry III's reign. When Bracton was eventually printed, it was by an anonymous promoter who gives high praise to his method, contrasting it with the wretched little works of crabbed technicalities which so far had appeared, and which obscured the view of law as a whole. At the same time he highly commends Bracton's Roman approach to English law[11]—and reminds us irresistibly that the year 1569 is in the midst of a period when Roman studies were reviving to some extent in England. Most striking of all is the appearance of a reprint of Bracton in 1640 on the eve of the struggle with Charles I when the famous interpolation on the subjection of the king to his equals played a part in parliamentary polemic.[12]

The legal literature whose *indigesta confusio* excited the scorn

of the first editor of Bracton was in fact typical of the products of our fifteenth century presses, and indeed of the sixteenth century too, for these works were being constantly reprinted all through Elizabeth's reign. To this group of publications we must now turn our attention, for its general character and the light which it throws upon the attitude of the fifteenth-century lawyer to his books are indicative of the results obtainable from a combined study of bibliography and legal history.

Beginning with the treatises printed before 1500, it must be admitted that they are neither numerous nor interesting, with the sole exception of Littleton's *Tenures*. The first five editions of this famous work are undated, but four of them are certainly before 1500; the conjectural dates assigned to them are 1481, 1483, 149—, and 1510.[13] Sixty-five editions by 1640 and four editions of Coke's *Commentary* upon it down to the same date attest its popularity. In essence, it was a student's introduction to legal studies and was used as such until almost the end of the eighteenth century. Indeed, the name "Littleton" became almost a synonym for "elementary manual"; a beginners' book of French has been found with the title *The Frenche Littelton: A most easie, perfect, and absolvte vvay to learne the Frenche tongue*.[14] The author's plan of writing for beginners fortunately compelled him to abandon a great deal of the heavy mass of technicality which by now enshrouded the law of real property, and to confine himself (for the most part) to matters of broad principle. The result is an admirable piece of dogmatic legal writing. Littleton died in 1481, and if the conjectural date of the first edition is correct, then he may have been the first English lawyer to see his own book in print.[15] But even in this treatise it is apparent that a spirit of exaggerated technicality was oppressing the law, however much he tried to conceal it, and in the other publications of the time this is clearly demonstrated. Littleton's book borrowed its title from an older anonymous treatise written a century earlier and generally known as the *Old tenures*,

which Pynson printed in 1496. Compared with Littleton's book, the *Old tenures* is a mediocre piece of work, but, as we shall see, the lawyers of the reigns of Henry VII and Henry VIII had a taste for this crabbed and inelegant literature for which the printers seem to have reserved their most battered fonts of type.

Among the other works which must be placed beside the *Tenures*, *old* and *new*, is a little tract called *Novae narrationes*, printed according to Mr. Duff in "England, before 1500?" It is merely a collection of declarations, with a few comments which were "new" in the earlier days of Edward III.[16] If there had been an early edition of Bracton in the fifteenth century to set beside the elementary handbook of Littleton, it is more than likely that depressing little tracts like the *Novae narrationes* would not have been printed; but fate ruled otherwise, and the years after 1500 saw a long succession of editions of this and many other small works of a similar nature, with the result that English law retained its medieval character until an unduly late period in the eighteenth century.

If another example be needed, we can take the *Old natura brevium*.[17] This work was about a century and a half old when Pynson printed it in 1494, and the extent to which it was out of date may be judged from the radical revision which it received at the hands of "the most Reverend Judge Sir Anthony Fitzherbert," who based upon it his *New natura brevium* which went through numerous editions between its first appearance in 1534 and its last in 1794. As often happens to lawbooks, the later editions are buried beneath the notes of subsequent editors who have endeavored to renovate a work which is really obsolete.

This fundamental lack of significance from which the treatises suffer in this period is really typical of English law for some centuries to come, and so it is to other types of lawbook that we must turn if we would discover the spirit of the law and trace its workings. First there are the statutes. One of our earliest

printed lawbooks was the *Nova statuta* set forth by Machlinia in 1484,[18] which was in fact preceded by a volume of abridged statutes in 1481 by Lettou and Machlinia. Pynson seems to have put out two more abridgments simultaneously in 1499. But most important of all, we find Machlinia printing the statutes of 1 Richard III (1483) in 1484, while Caxton followed with the statutes of 1–4 Henry VII in 1489. To the enterprise of these two printers we therefore owe that enormous series of statutes published immediately after their enactment which extends from 1484 (with a few gaps) until the present day. The stream of legislation must have flowed more quickly (as in fact it did) as a consequence of this newfound means of placing the results in the hands of all concerned more effectively than by the old system of oral proclamation and the circulation of manuscript copies.

The possibility of publishing legal material as soon as it came into existence seems to have at first influenced only the stream of statute law. Only very slowly did it make itself felt in the other great source of legal rules, decisions, and the slowness of the process is of great interest to the legal historian.

One of the greatest differences between the common law and other systems is its habit of looking to court decisions rather than to an authoritative text such as a code or a renowned treatise for guidance in developing legal doctrine. At the present day lawyers have to take notice of large numbers of cases, and, as we have remarked, the law publishers have met this situation by a remarkable organization for the rapid reporting, annotation, and distribution of judicial decisions. One of the most fundamental questions in Anglo-American legal history is that of the rise of this attitude. For in point of fact the development was slow, and no precise date can be assigned as the beginning of the present system. In the Middle Ages our law seems already turning in this direction when we see the thousands of cases reported in the long series of *Year books* which extends from the last years

of the thirteenth century down to the reign of Henry VIII. It is clear that these *Year books* were much studied, for there are many manuscripts extant wherein readers arranged cases or abstracts of cases under alphabetical heads of subjects; one of these was printed by Le Tailleur at Rouen for Pynson in 1490 and is generally known as Statham's *Abridgment*. In 1516 it was followed by the *Graunde abridgment* of Fitzherbert, and the race still flourishes (in modified form) on both sides of the Atlantic. For our purpose, however, it is the publication of the *Year books* themselves rather than of abridgments of them which lies at the root of the question whether the printing press is at all responsible even in its early days for the growth of the principle of precedent in English law. Did printers turn out *Year books* because lawyers wanted the latest news of binding decisions, or did the idea that decisions had to be watched carefully only arise after the press had in fact put forth a fair number of volumes of such material? In short, were our early printed decisions the result or the cause of the principle of precedent?

An examination of the earliest editions will throw some light upon this problem.[19] Our oldest print seems to be the undated edition of the years 33–37 Henry VI (that is to say, of cases decided between 1454 and 1459), which came from the press of Lettou and Mechlinia about 1481; the cases were therefore not quite a generation old when they were printed. As for the decisions made in this year 1481, we find them unpublished until 1520, after a lapse of nearly forty years. Between 1490 and 1499 we find only a few isolated years of Edward IV appearing in print, and it is therefore clear that so far at least there had been no systematic publishing of any *Year books*, and certainly no attempt to publish what we may call "current reports" to accompany the current statutes which were already an established series.

The year 1500 saw a new departure. At that moment Pynson printed the *Liber assisarum* (or rather, an abridgment of it) in

a stout volume, consisting of certain types of cases in a series of fifty years covering the reign of Edward III. This volume is remarkable in many ways:[20] first, it is considerably bigger than any other so far printed; second, it covers a long period of years (half a century) as a unit, although in the form of an abridgment rather than a full and continuous text; and third, it is by far the remotest in date (1327–77) from the date of printing of any *Year book* so far. We may therefore interpret its appearance as indicating a desire for remoter material in point of date, and a longer range of continuous reporting. This impression is confirmed by the appearance two years later of an edition in one volume (not separate booklets) of the years 1–8 Henry VII.[21] Here we get a longer range and a striking tendency to print more up-to-date cases (the interval is only ten years). At the same time we also find an interest in remoter years, for there appeared simultaneously an edition of some early years of Edward IV and shortly afterward some years of Henry IV.

The first half of the sixteenth century witnessed a veritable flood of *Year books*, published for the most part haphazard as far as we can see. The publication of each year in a separate little volume seems to be the rule (with very few exceptions); there is a slight tendency to publish more recent cases after intervals of only ten or fifteen years; but at the same time remoter years are getting into print, such as the middle of Edward III's reign. More than this cannot be said without delving into a formidable mass of detail involving many undated prints. One thing is clear, however, and that is that there were now in print a considerable number of *Year books* containing cases selected from over two hundred years of our legal history, and some of these were reprinted several times. The learned public was by this time genuinely interested in case material, old and new. Interest in the older decisions may have been aroused by the fact that the *Abridgments* of Statham and Fitzherbert contained a great proportion of early cases, while it is equally cer-

tain that little distinction was drawn between cases coming from different dates. One important element in the modern system, therefore, was still lacking, namely, concentration upon the most recent cases as superseding the older ones.

At this point there arose a man who had the imagination necessary to put order into the disorderly mass of *Year books*. This was Richard Tottell, and to him the legal profession owes perhaps more than it knows at present. In 1553 he obtained a monopoly of publishing lawbooks under professional supervision, and he used this power to give law publishing its modern appearance. He filled the gaps in the existing series, and published whole reigns in single volumes. To facilitate citation he standardized the foliation of the *Year books*. More than that, he attempted something like the "key-number" system which has been developed in this country, for he furnished his reports with references to the *Abridgments*, and reprinted the *Abridgments* with cross-references to his editions of the *Year books*. As a result, Tottell's sets bear a real resemblance to the closely knit and organized series of the modern systems of related reports and digests. To make the *Abridgments* less bulky, he even tried small print and thin paper. To say this will be to place Tottell in a very high position in our legal history; he first treated our medieval heritage of the *Year books* with what were then, and still are, "modern methods." Tottell was not a lawyer like John Rastell, but a successful business man who had the uncanny faculty of his kind in discerning the early movements of public demand, and being ready to meet it. His judgment, no doubt, was that lawyers seemed interested in these scattered specimens of *Year books*, and so he determined to give them complete sets, co-ordinated with the rest of their legal literature. In so doing he turned what may have been merely a passing mood into a permanent mode of legal thought, which after his day was to undergo the most far-reaching developments. This is a high title to fame in our legal history, and if it has been obscured, it

is only because the immortal *Miscellany* has even exceeded it as a contribution to English culture.

If we conclude at this point, it is not because the resources of bibliography are exhausted; all through the history of English law the influence of printers and publishers has been making itself felt in the development of the law, so dependent are we upon our books, and so susceptible to their influences. We have urged that no student of legal history can afford to ignore the results obtainable from the science of bibliography, and the foregoing remarks will serve as examples of the relationship between the two. They have been confined to England, and extended beyond the limits of the fifteenth century, simply because the English lawbooks have been more closely studied than those on the Continent, and because most of them are later than 1500. But if skilled bibliographers were to explore the legal literature of other nations (and also enlarge our knowledge of our own), they may be assured of the sympathetic interest and gratitude of many legal historians.

Notes

1. In his admirable article, "Bibliofilia," in the *Enciclopedia italiana*, VI (1930), 933*a*.

2. For a long list of these bibliographies see Pertile, *Storia del diritto italiano*, II, ii, 118.

3. The reference is, of course, to the late George Dunn, whose legal collection is now in the library of the Harvard Law School. He is the subject of a short memoir in the *Transactions of the Bibliographical Society*, Suppl. 3. The bibliography of English lawbooks can be studied in the sale catalogue of his collection, and in the following:

Worrall, *Bibliotheca legum angliae* (2 vols., 1788 and several other editions).

Maxwell, *Bibliography of English law to 1650* (London, 1925).

Winfield, *Chief sources of English legal history* (Harvard University Press, 1925).

Beale, *Bibliography of early English law books* (Harvard University Press, 1926).

Soule, "Year book bibliography," *Harvard law review*, XIV (1901), 556–87.

Pike's *Year book 17 Edward III* (London, 1901) contains some additional information, at pp. xii–xxv.

Van Vechten Veeder, "The English reports," *Select essays in Anglo-American legal history* (Boston, 1908), II, 123–68.

Wallace, *The reporters* (4th ed.; Boston, 1882).

Fox, *Handbook of English law reports* (London, 1913).

Holdsworth, *History of English law* (3d ed.; London, 1922–26), in the following places: II, 512–76; IV, 112–21, 307–13; V, 8–25, 50–60, 130–34, 162–67, 261–78, 355–412, 456–90, 497–99; VI, 360–79, 551–624, 683–99.

4. Such works as Lipenius and De Bure are at the best very incomplete and uncritical guides.

5. *Geschichte der Quellen und Literatur des canonischen Rechts* (3 vols.; Stuttgart, 1875–80). There is also a great deal of information on early editions in Stintzing, *Geschichte der populären Literatur des römisch-kanonischen Rechts in Deutschland* (Leipzig, 1867).

6. *Geschichte des römischen Rechts im Mittelalter* (2d ed.; Heidelberg, 1834–51). For other works see the Bibliography in *Cambridge Mediaeval History*, V, 921–33.

7. E.g., the works of Pertile and Salvioli in Italy; Viollet, Tardif, and Glasson in France; Stobbe and many others in Germany (for whom see Schulte's useful *Lehrbuch der deutschen Reichs- und Rechtsgeschichte* [Stuttgart, 1892]).

8. Three of these (Beale, T 406*a*, T 406*b*, and T 408*a*) are not in the *Short title catalogue;* four of them were printed abroad.

9. See in general Hilary Jenkinson, "English current writing and early printing," *Transactions of the Bibliographical Society*, XIII, 273–95.

10. For Bracton's life and work see Holdsworth, *op. cit.*, II, 230–90. There were some later revisions of Bracton which embodied the important changes under Edward I, but the only one to have any success was Britton's, which was printed in 1540.

11. The anonymous editor's words are eloquent enough to deserve quotation: "Iustiniani Institutionum methodum, juris nempe civilis Romanorum quoque peritus, videtur sibi ad imitandum proposuisse, ac eadem fere ratione ad leges Anglicanas commodo et perspicuo ordine tradendas progreditur. Quod eius institutum, illis quibus in hoc genere indigesta confusio semper displicuit atque multum in dies et molestiae et impedimenti obiicit, non potest non esse inprimis et iucundum et utile. Videmus quantum pauci illi libri quos eruditi nonnulli, non multi tamen, de juris nostratis argumentis vel titulis (ut vocant) aliquot recte et ordine non malo aediderunt, quales sunt Litletonus *De Tenuris*, Fitzherbertus *De Brevium Natura*, Stanfordus *De Placitis Coronae et Regia Präerogativa*, et eius generis reliqui, studiosis in hac facultate tyronibus adiumenti afferant. Quanto magis recte dispositam et perspicuo facilique ordine ac methodo traditam totius huius artis rationem atque epitomen ingenio nostro et memoriae, tam ad intelligendum et iudicandum quod de omni hoc studio sentiri debet, quam ad conservandum et retinendum quod in eo sumus assecuti, mirifice prodesse opportet."

12. For discussions of this passage see Bracton's *Note book*, ed. Maitland (Cambridge, 1887), I, 29–33, and McIlwain, *High court of Parliament* (New Haven, 1910), pp. 101–3. The passage also occurs in the early manuscript of Thornton's *Summa de legibus*, in the Harvard Law Library.

13. *Short title catalogue*, 15719–23.

14. See Mr. Pollard's article on this work in *Transactions of the Bibliographical Society*, XIII, 253–72.

15. For a full discussion of his work and its place in legal literature see Holdsworth, *op. cit.*, II, 571–90.

16. For a description see *ibid.*, II, 522, 523.

17. See *ibid.*, p. 514.

18. The *nova statuta* are those from the first year of Edward III onward; those before Edward III's reign are *statuta antiqua*.

19. On this matter see Bolland, *Manual of year book studies* (Cambridge, 1925), pp. 61–82.

20. Duff, *Fifteenth century English books* (1917), No. 37; *Short title catalogue*, 9603.

21. Beale, R 400; not in the *Short title catalogue*. The only copy seems to be in the Harvard Law Library. Bolland (*op. cit.*, p. 67) dates it about 1505, following Soule in *op. cit.*, p. 565.

THE INFLUENCE *of the* MATHEMATICAL WORKS *of the* FIFTEENTH CENTURY UPON THOSE OF LATER TIMES

By DAVID EUGENE SMITH

IT IS needless to say to an audience concerned with matters bibliographical that just as no physical measurements are ever exact, so no chronological eras ever have precise limits and no discoveries have any absolute beginning. The Dark Ages, the Middle Ages, the Renaissance, and the century of the reform of the calendar are hardly more today than somewhat inconvenient terms invented for some merely temporary convenience.

So when I am asked to speak of the influence of the mathematical works of the fifteenth century upon those of the sixteenth, the question relates to a subject that has no precise definition and to two periods of time that have no precise intellectual limits. The term "mathematics" in the period which is popularly called the Renaissance meant to many scholars little more than astronomy; to others, little more than astrology; to others, the geometry of Euclid; and to others, the mysticism of numbers; while to relatively few it covered not only Euclidean geometry, the number theory, and algebra, but also such subjects as astronomy, optics and perspective, conics, calendar reform, and mechanics.

What I shall attempt, therefore, is first to mention certain general features of mathematics, broadly considered, that were somewhat prominent about the year 1400, having been passed along from the preceding centuries; then to mention certain

features which attracted particular attention in the fifteenth century, showing themselves especially in the printed literature; and, finally, to speak of the apparent influence of this material upon the mathematical literature of the century beginning in the chronological vicinity of 1500.

That this plan is not a satisfactory one is evident from the fact that a subject like the calculus has its initial stages in ancient times; is lightly touched upon in the thirteenth and fourteenth centuries, as by Jehudah Barzilai and Nicole Oresme; seems quite forgotten in the fifteenth, starting almost *de novo* in the sixteenth, and comes nearly to maturity in the seventeenth. That is, the fifteenth century developed nothing new in this field that it could pass on to its successor, at least in printed form.

In spite of this situation, however, the century in which printing, in the common meaning of the term, made its beginning in Europe can hardly fail to reveal much that is of interest to the historian, the bibliophile, and the mathematician. It is this interest that I shall seek to encourage.

In mathematics, as in most of the other pure or applied sciences, the fifteenth century produced relatively less that was important to the progress of knowledge than the two centuries that preceded. This was not because of any lack of new publications; on the contrary, the very ease of production seemed to replace quality by quantity. The universities were concerned rather with teaching or in making known the works of the mediæval contributors than in making new inroads into the field of mathematics. Those whose interests lay in the mathematical disciplines seemed quite content to rest upon the discoveries or patient work of such predecessors as Leonardo Fibonacci and Jordanus Nemorarius in the early part of the thirteenth century, Sacrobosco and Campanus in the generation following, and Nicole Oresme in the fourteenth century, perhaps with a feeling that the field of mathematics had been fully explored.

The situation was not unlike that in Great Britain in the eighteenth century, when mathematicians seemed satisfied to consider the achievements of Newton as barring the hope for further advance. In both cases there was a distinct decline in the output of original work in mathematics.

There was, however, this encouraging feature—that men's minds turned to the dissemination of knowledge even if not to original contribution to the science. In the first half of the fifteenth century this is seen in the increase in the production of manuscripts, and in the second half in the printing of books. Riccardi,[1] whose lists are far from being complete, records 214 works on mathematics, pure and applied, printed in Italy alone in the incunabula period, with 1527 in the sixteenth century—a very respectable beginning.

The general range of mathematics in the fifteenth century differed greatly from that of the Greeks and even from that of the so-called Dark Ages, and far more from that of today. A brief bibliographic survey of the period may properly include the following topics: (1) arithmetica, (2) algorism, (3) abacus arithmetics, (4) commercial books, (5) almanacs, (6) astronomy, (7) calendar reform, (8) algebra, and (9) geometry, with some reference to other topics, the sequence having no special significance.

The subject of "weights and measures" is too extended to be considered in this paper. The large number of units required before the invention of the decimal fraction, or even of a convenient way of working with common fractions, and the large number of local systems which grew up before the trade routes were such as to render intercommunication convenient among cities gave rise to an extensive literature. Indeed, so potent is custom that the number of systems of measuring is even today very large.

1. *Arithmetica*

The Latin term *arithmetica* is here taken so as not to confuse its meaning with that of the modern word "arithmetic." In ancient times it meant the theory of numbers, a subject due chiefly to the Pythagorean influence but, in the Middle Ages, based upon the work of Boethius (*ca.* 515), one of the first of its kind to appear in print.[2] Indeed, it may properly be called the first, since the *Tractatus ꝑportionum* of Albert of Saxony (*ca.* 1365), published *s.l.a.*, but not before 1481,[3] was devoted almost solely to the old and cumbersome treatment of ratios. Boethius has followed Nicomachus (*ca.* 100), who, although his inspirer, was never so widely recognized in the universities.[4]

This theory of numbers included the study of primes, squares, cubes, roots, and the abundant use of ratios which had been extensively developed because of the lack of a convenient symbolism for fractions. This type of number work had been the subject of study by such later writers as Martianus Mineus Felix Capella (*ca.* 420–90), whose *Opus Martiani Capelle de Nuptijs Philologie & Mercurij libri duo*, a medley of prose and verse, was printed at Vincenza in 1499;[5] Cassiodorus (*ca.* 470–*ca.* 564), whose *De quatuor mathematicis disciplinis compendium* was not printed in the fifteenth century,[6] but was well known in manuscript form; and Isidorus of Seville (*ca.* 600), whose *Liber etymologiarum* (Venice, 1472) contained a "liber tertius De vocabulo arithmeticę disciplinę," and shows the low state of learning, not merely from the seventh century for a period of eight hundred years, but also in the early stages of printing.[7]

In the Middle Ages the subject was studied extensively, as witness the works (printed in the fifteenth century) of such writers as Thomas Bradwardin (*ca.* 1290–1349),[8] Jordanus Nemorarius (d. 1236),[9] and Jean de Meurs (b. *ca.* 1310).[10]

The influence of such works, great as it was in the Middle Ages and the fifteenth century, was much more felt in the century following, as witness the number of editions issued from

the press. Even England, then rather remote from the centers of printing, felt it early, for Caxton's *Mirrour of the world or thymage of the same* (London, 1480), translated from the French, had a brief chapter beginning, "And after of Arsmetrike and whereof it proceedeth. . . . ."

2. *Algorism*

The algorisms were books devoted to practical calculations by the use of the Hindu-Arabic numerals, modified after their introduction into Europe at least as early as the tenth century. These numerals received much attention as a result of a translation (twelfth century) of a small work by Mohammed ibn Mûsâ al-Khowârizmî (*ca.* 820)[11] translated under the title *Liber Algoritmi*[12] *de numero Indorum*, or simply *Liber algoritmi*, whence the word "algorism." The imperial legions had carried the Roman numerals to all the civilized parts of Europe and North Africa, and even to the Near East, and these had become thoroughly fixed in the monastic centers of learning. The oriental numerals, looked upon at first as somewhat esoteric and the property of the astrologers and soothsayers, appealed to the Italian traders and finally became the recognized numerals of commerce. For this reason the books on algorism flourished more vigorously south of the Alps than in the northern countries, and more books on the subject were printed in the fifteenth century in Italy than in Germany, France, or Holland. If we dignify mere calculation by introducing it as a branch of mathematics, then the most commercially important influence of the fifteenth century upon the mathematics of the sixteenth is that of algorism upon the mercantile world at large.

The influence of algorism was not due to the tradespeople of Italy alone. As early as the thirteenth century Vincent de Beauvais (*ca.* 1250) had given it recognition in parts of his *Speculum majus*;[13] his contemporary, Johannes de Sacrobosco (John of Halifax, *ca.* 1200–*ca.* 1256), had made it even better known

through his lectures at Paris and through his popular *Algorismus;*[14] and Alexandre de Villedieu had taught the subject at Paris (*ca.* 1225), had written *De arte numerandi*, and had done perhaps more than any other person of his time to interest the people in the oriental numerals through his rhyming production, the *Carmen de algorismo.*[15] At about the same time Jordanus Nemorarius (*fl.* 1225) may have written an *Algorismus demonstratus*,[16] but in any case the subject was not unfamiliar to the intellectual leaders of the thirteenth and fourteenth centuries.

The fifteenth century naturally saw it made more widely known, first through the efforts of scholars like Prosdocimo de Beldamandi (*d.* 1428), who lectured at Padua and who wrote for the Latin schools an *Algorismi tractatus*,[17] and then through the customs of the mercantile world in Venice, Pisa, Genoa, and other Italian towns, and to a lesser degree in Vienna and the Hansa cities to the north.

It was, however, to the printing press of the fifteenth century that the rapid spread of the new numerals was due, and to it the sixteenth century owed its almost complete conversion from the Roman to our more convenient modern symbols for number. Anonymous books upon algorism began to appear in Italy about 1476–78.[18] One may have been printed even earlier, in the German language, also anonymous.[19]

3. *Abacus Arithmetics*

Europe inherited from the classical period the method of calculating by means of disks, counters, beads, or some other similar device. Although computation was quite possible by the aid of the Greek numerals, and addition and subtraction were rather easier by the Roman numerals, after they were once written, than by our own, still it was in general more convenient to use the *calculi* ("pebbles"), whence the verb *calculare*, or to adopt some other type of abacus.[20] Books in which the counters were used might properly have been called *libri abaci*, and frequently

were designated by the name *abacus;* but as is so often the case, the name came to be applied to any kind of work on computation.[21] For purposes of classification, however, we may use the term to mean a treatise on computation by counters. Such works, in manuscript form, were well known even before the twelfth century, as is seen by references in a treatise on the subject written about 1200 by Turchillus (Thurkil).[22]

Computation by the aid of counters was passed on from Roman times to the Middle Ages and is connected with the Court of the Exchequer (the Chambre de l'Echiquier of the French, and the Scaccarium of the Latin writers).[23] The Italian merchants having discarded the use of counters relatively early, books upon this use were not printed in Italy. To the north of the Alps, however, they are found at the close of the fifteenth century and, particularly in the Teutonic countries, they were very numerous in the century following.

The first printed work on the subject was a Latin textbook which appeared in three editions from the same press at Leipzig (*ca.* 1490–95), probably written by Johann Widman, who lectured on "Regulas Algobre" at Leipzig. The title was *Algorithmus linealis,* which "apud nostras appellata est calculatio." The name became quite common in spite of the fact that *algorithmus* originally had nothing to do with casting counters on lines, and *linealis* (referring to the lines) had nothing to do with algorism.

At about the opening the sixteenth century saw, in Germany, many textbooks devoted either entirely to computation by counters, like Balthasar Licht's *Algorithm linealis* (Leipzig [1500]) or partly so, like Johan Huswirt's *Enchiridion nouus Algorismi* (Cologne, 1501), with its "Tractatus secundus de proiectilibus." In France the subject attracted a little attention about the same time,[24] but it was in Germany that the influence of the commercial customs of the preceding centuries showed themselves strongly. Jakob Köbel's popular arithmetics,[25] beginning in 1514 and passing through many editions, did much

to establish counter reckoning in the commercial schools of that country. Still more powerful were the books of Adam Riese,[26] the *Rechenung auff der linihen vnd federn* appearing in 1522. More than forty editions of his arithmetic were published in the sixteenth century, and several in the one following. So far as German commercial arithmetics are concerned, the greatest influence of the fifteenth century customs upon those of the sixteenth century is seen in the well-nigh universal use made of "reckoning on the line," that is, with counters on a ruled table. A boy was taught to reckon *auf den Linien* and so to know the lines (*die Linien zu erkennen*). He was taught to "lay" the sum (*Leg zum ersten die fl.*), perhaps the origin of our expression "to lay a wager." If he could compute like the Italians, with a pen, he was said to be able to reckon "on the lines and with the pen," an expression used in the title-page of Riese's book.

The first arithmetic printed in England that had much influence was Robert Recorde's *The grovnd of artes* (London, *ca.* 1540–42), of which there were at least eighteen editions in the sixteenth century. In this the computation by counters has a prominent place, showing that the German abacus method had a large following in Great Britain. It would be interesting to know how much, if any, of this German method of computing influenced Recorde through Roger Ascham, who had returned to London about this time after a study of German schools and must have come in contact with him at court.

TABLE

Language	Per Cent
German	74
French	8
English	11
Others	7
Total	100

The way in which this influence, starting chiefly in the German states, affected Europe outside of Italy in the sixteenth

century may be seen from the table of different editions of arithmetics giving more or less of the computation by counters (table on preceding page). The list is made chiefly from the examination of the texts, but partly from that of the title-pages, and hence the percentages are not exact. They serve, however, to show the spread of the method. In the seventeenth century it rapidly fell into disuse.

4. *Commercial Books*

Since a business arithmetic could be (1) an *algorismus*, (2) a book in which the method of counters alone is used, or (3) a combination of the two, it is desirable to speak briefly of these books from the standpoint of commercial content, and see how the early Italian and German publications affected the handbooks of the sixteenth century.

As already stated, the first dated book on algorism was printed at Treviso in 1478, *Incommincia vna practica molto bona et vtilez a ciaschaduno chi vuole vxare larte dela merchadantia. chiamata vulgarmente larte de labbacho.* It was purely commercial in nature, being designed for the use of the merchants of Treviso and Venice. It seems to have had but little influence upon the writers of arithmetics, having never been reprinted or even referred to by them. Its chief value lies in its presentation of the ordinary operations with numbers.

It was not books of this nature, however, that exercised the greatest influence upon the commercial arithmetics of the next century. It was rather the popular books devoted to commercial customs, such as the *Qvesto e ellibro che tracta di Mercatantie et vsanze de paesi* of Giorgio Chiarino (Florence, 1481), a compilation of the measures and systems of exchange of all countries trading with the business centers of Italy.[27] Its influence was increased through Pacioli's (1494) appropriating much of its material. A much more noteworthy work was that of Piero Borghi,[28] beginning *Qui comenza la nobel opera de arithmethica.*[29] This work had a wide influence, and evidently suggested to

several writers of the fifteenth and sixteenth centuries the lines which they should follow in treating of commercial arithmetic. This is particularly seen in the treatise of Luca Pacioli,[30] *Sūma de Arithmetica Geometria Proportioni & Proportionalita* (Venice, 1494; 2d ed., Toscolano, 1523), which was a summary of the general mathematical knowledge of the last of the fifteenth century. Pacioli borrowed freely, and without any acknowledgment (as was a rather common practice in the early days of printing), from such contemporary writers as Pietro Franceschi and Chiarino and such earlier ones as Euclid, Ptolemy, Leonardo Fibonacci, Jordanus Nemorarius, Sacrobosco, Biagio of Parma, Prosdocimo de Beldamandi, and Suiseth[31]—a fact which at least shows his range of reading and the influence of the early writers upon those of the fifteenth and sixteenth centuries. The work was so full of errors, however, that Cardan devoted a chapter in his *Arithmetica* (1539) to excusing them. Pacioli also edited Euclid (1509), but the work was of little consequence.

Besides this compendium there was the more modest arithmetic of Filippo Calandri (Florence, 1491), the first Italian book of its kind with illustrations, which in its way exerted considerable influence. In Germany there was Johann Widman's *Behēde vnd hubsche Rechnung auf allen kauffmanschaft* (Leipzig, 1489), also mercantile and also important in determining the course of arithmetic in the Teutonic countries. We have simply to examine the list of arithmetical topics and the customs of exchange and trade in France, Holland, and England to see how influential were the Italian and German books already mentioned upon the commercial textbooks of the succeeding century.[32]

As to attempts to combine the commercial and the theoretical, they were in general unsuccessful. One of the most noteworthy was that of Bishop Cuthbert Tonstall, whose *De arte svppvtandi libri qvattvor* (London, 1522), the first dated English arithmetic, was too ponderous in style and content to meet the popular demand.

In speaking of the commercial books, mention should be made of the fraction, since this entered so largely into both business and scientific work. The common fraction, so called to distinguish it from the sexagesimal ("physical," "astronomical"), was well developed before the fifteenth century, and all that this and the following century did for it was to make more evident that, for elaborate computations, it must soon become obsolete.

For scientific work the sexagesimals, such as $7°15'28''19'''$, and so on, or our present 2 hr. 16 min. 10 sec., had been in use since the classical period, having been inherited by the Middle Ages from the Greek astronomers, and were used by most fifteenth-century writers in this field. They therefore found place in nearly all the printed books on the subject. As a result, the sixteenth-century writers used them even after decimals became known, and rather unfortunately they still hold their position except for the fractions of a second, where decimals are now used. Instead of writing $5°.555$, we adhere to $5°28'32''$, simply because our tables and our habits are so fixed that we have trouble in getting release.

The sixteenth century began to awaken, however, to the fact that its inheritance from its predecessor, in the way of fractions, was a liability rather than an asset. Indeed, some evidence of the same feeling already showed itself in the fifteenth century. This is seen in numerous manuscripts in the form of a rule for dividing a number by multiples of 10. For example, in Chuquet's manuscript of 1484, the number 503 is divided by 10, by dividing 50 by 1 and dividing 3 by 10, the quotient being $50_{\frac{3}{10}}$, analogous to our $50.3 \div 1 = 50.3$. This plan led Pellos (1492) to divide 796,548,397 by 20 by first dividing by 10 and actually using our decimal point, the problem reducing to $79{,}654{,}839.7 \div 2$, giving 39,827,419 with a remainder of 1.7, which was to be divided by 2, or 17 was to be divided by 20, the latter form $(\frac{17}{20})$ being the one chosen.

The sixteenth century was not long in accepting this legacy.

Christoff Rudolff (*Exempel-Büchlin* [Augsburg, 1530]) used decimals in computing compound interest, where 393|75 is used for 393.75, and multiplications by integers are carried on as at present. It was not until 1585, however, that what is usually considered a separate treatment of the subject appeared (a pamphlet, *De thiende* [Leyden, 1583]; with a French translation, *La disme* [Leyden, 1583]), and not until the close of the century that the modern symbolism began to be used. It was the invention of logarithms (1614), or rather the improvement made by Wright when he translated the work from Latin into English (1616), that gave decimals a high standing in the mathematical world. Nearly two centuries had still to pass, however, before decimals began to become popular in business and scientific circles. Not only did printing tend to standardize the content of arithmetic, but to even a greater extent did it standardize the symbols, the operations, and the language of all parts of mathematics. For example, it is to the fifteenth century that we owe the following:

1° for "first," the Italian *primo;* 2° for *secondo;* 3° for *terzo*, etc.

% for the Italian *per cento* [Lat. *per centum*, but the usage came from the Italian merchants through "per c°" and "per c̃"].

+ and −, the former being a contraction of *et*, used in medieval Latin manuscripts, and seen in later form in our "&"; and the symbol − being used to show an omission, as in *Sūma* for *Summa* [Pacioli's work of 1494]. It had various forms, as in the French *hôtel* for *hostel*, the German *über* for *ueber*, and the Spanish *cañon* for *canyon*. The Italian used both − and ~, but the former conquered and became our minus sign.

"Proportionality" [*proportionalita*] for "proportion," a usage which persists in certain parts of America and Europe.

"Proportion" for "ratio," a usage very common in the English-speaking world, as when we say "I will divide this in the proportion of 2 to 3," the schools having failed to impose their use of "ratio" upon the business world.

"Rule of three," an expression still used commonly in certain European countries, although the original rule has been quite forgotten.

"Profit and loss," a term which persists, being an inheritance from *guadagni perdite* of the Italian arithmetics of the incunabula period.

"Reckoning," a term which was stamped upon our language by the Rechenschule with its Rechenmeister in Germany in the fifteenth century and is not yet obsolete.

Long division in its present form developed chiefly in the fifteenth century, although a step in this direction had been taken by Maximus Planudes [*ca.* 1340] in Constantinople.[33] It appears in a less convenient form than ours in an Italian manuscript of about 1460, now in the library of Mr. George A. Plimpton. The first printed book in which it is found, and in a form closely resembling the modern one, is Filippo Calandri's arithmetic of 1491, already mentioned. The Italians gave to this method a name [a *danda*] which they had already used for a less convenient one. A later writer, Cataneo [1546], explains the term as follows: "È chiamato a danda.... perche à ogni sottration fatta nel operare se li da vna o piu figure dal lato destro" [1567 ed., fol. 15].

Similarly, the problems of Italy in the fifteenth century, which were passed along to the sixteenth in France, Germany, and other European states, dominated their arithmetics for four centuries and were, in turn, passed on to America. For example, partnership of all kinds (*compagnie i tutti modi*), such as those involving time (one of the forerunners of our stock companies), barter (the old *baratti*), and pasturage (*soccide de bestiani*), all started in Italy and were all known until the nineteenth century in our country. A similar illustration is seen in our double-entry bookkeeping, found in Pacioli's *Sūma* of 1494, and originating in the counting-houses of Northern Italy in the fifteenth century.

5. *Almanacs*

The wide use of almanacs in the sixteenth century was due largely to German influence. Almanacs, calendars, and *computi* were inheritances from the Middle Ages in all church and university centers, but Germany took the lead in printing such literature in the fifteenth century. The *Gesamtkatalog der Wiegendrucke* lists one almanac by Gutenberg as early as 1448, and gives the total number listed, under „Almanach" alone, before 1501 as 268, not counting several xylographic pieces.

Closely related to the almanac is the *computus* or *compotus*, designed to furnish easy rules for fixing the feasts of the church. The Middle Ages contributed such noteworthy examples as *De temporum ratione* of Bede (*ca.* 673–735); *De anni ratione, seu vt vocatur vulgo: Compotus ecclesiasticus*, of Sacrobosco (*ca.* 1200–

1256); the *Massa compoti* attributed to Alexandre de Villedieu (*ca.* 1225, besides others by such relatively minor writers on this subject as Gerlandus (eleventh century), Turchillus (Thurkil), Helperic, Fulbert of Chartres, Michael Scot, and Manfred of Magdeburg. There were also a *Summa magistri Wilelmi de compoto* (1163), a *Compotus Petri* (1171),[34] and numerous other works upon the subject. To these books are due such mnemonics as

> Thirty days hath September,
> April, June, and November;

verses often found, in substance, in late medieval Latin. They also contain directions for finding certain similar facts by the aid of the fingers, a work of this kind being called a *computus manualis*.

The most widely known of these manual *computi*, and the one which, through its great popularity between 1483 and 1501, influenced the sixteenth century to a marked degree, was the *Computus manualis* of Anianus (*ca.* 1275). No less than thirty-four editions of this work appeared before 1501, and so great was the impetus that twenty-eight more were printed in the next forty years, not to mention the so-called translation in the *Cuer de philosophie*, which had eighteen editions between about 1504 and 1538 inclusive.[35]

Less popular than the work of Anianus was the *Computus ecclesiasticus & astronomicus editus a Magistro Arnaldo de villa Noua*.[36] It represents one of the final efforts to retain for the Roman numerals their medieval supremacy in church literature of this kind.

6. *Astronomy*

Astronomy, the foundation upon which rested the almanacs and *computi* (*compoti*), not to speak of astrology, played an important part in the training of church scholars, especially before ecclesiastical calendars began to be computed for long periods in advance. The necessity for fixing Easter and other movable

feasts for each religious center was so great that the church naturally came to monopolize the training of those charged with this duty. In the Saracenic period Spain was the center of this phase of educational activity, the Mohammedans and Jews having quite as many problems with respect to their own calendar as the Christians had with theirs. From schools like those at Toledo, Salamanca, and Cordova the study of astronomy worked north through such intellectual centers as Montpellier, Toulouse, and Marseilles,[37] and then still farther north to the newly founded University of Paris. In the twelfth century Ptolemy's *Almagest* was translated from the Greek into Latin (*ca.* 1160), and a little later (1175) from the Arabic into Latin by Gherardo of Cremona, having been translated from the Greek into Arabic in 827.[38]

The general interest in the subject in the thirteenth and fourteenth centuries is seen in such works as Sacrobosco's *De sphaera* (*ca.* 1250), Bartolomeo da Parma's *Tractatus sphaerae* (*ca.* 1290),[39] and Nicole Oresme's *Traicte de la sphere* (*Traité de la sphère*, before 1377).

It is also seen in the teachings of such scholars as "the wizard Michael Scot" (*fl. ca.* 1225), who stood for Aristotle's theory of homocentric spheres as opposed to the eccentrics and epicycles of Ptolemy, but is chiefly known for his writings on astrology.[40] In the century following, Franciscus de Mayronis, Albert of Saxony, and Nicole Oresme all suggested that the eighth sphere of the fixed stars might be stationary and the earth be in motion, thus taking a step toward the Copernican theory.[41] In this connection a word should be said with respect to the work of Capella, already mentioned, which had great popularity in the Middle Ages, particularly in church circles. Its chapter "Tellus quod non sit centrum omnibus planetis" may well have had a beneficial influence in connection with the newly awakened interest in astronomy in the two centuries here considered.

The influence of the Jewish writers from the twelfth to the

fifteenth centuries was also felt. Led, as the Christians and Saracens were, to the study of astrology, they also contributed their share to the related study of geometry and trigonometry. Thus we find the names of Abraham bar Chiia (Savasorda),[42] who wrote a work later known as the *Liber embadorum*, or "Book of surfaces"; Rabbi ben Ezra, mentioned later; Salomon Kohen of Toledo (d. 1247), who wrote on the *Almagest;* and Levi ben Gerson (1288–1344), whose contributions include some work on trigonometry. The persecutions of the Jews in the fifteenth century were such, however, as greatly to lessen the possibility of their exerting any marked influence upon the century following. In general it may be said that the greatest contribution to astronomy made by them in the Middle Ages was in the perfecting of the older tables.

The influence of these earlier works was very marked in the fifteenth century and later. Sacrobosco's *De sphaera* was printed (Venice, 1472) and became, as the large number of later editions show, the most popular treatise on the subject for at least one hundred and fifty years. Ptolemy's *Almagest*, already mentioned, was again translated from the Greek into Latin, this time by George of Trebizond (Georgius Trapezuntius, *ca.* 1396–1484) in 1451.[43] It first appeared in print in 1496, in an epitome left by Regiomontanus (1436–76),[44] and in complete form in 1515.[45] In the same period Nicholas Cusa (1401–64), often incorrectly spoken of as an important precursor of Copernicus, a prince of the church, gave much attention to astronomy. His *Opera* appeared in Paris in 1511.

In the fifteenth century there were lectures on astronomy in all the universities of importance. For example, Giovanni Bianchini (*ca.* 1450) was professor of the subject at Padua, and both Peurbach and his pupil Regiomontanus lectured not only in the Teutonic cities but also in Italy. Neither of the latter two was a great astronomer, but each was a good expositor, their treatises being printed posthumously.[46]

The great interest of the sixteenth century in carrying on this work is seen in such editions of the classics as those of Menelaus (*ca.* 100), published by Maurolycus (Paris, 1558; there was also a seventeenth-century one by Mersenne, Paris, 1644), and of his contemporary Theodosius (*ca.* 100), published in various editions after 1518.

It must be borne in mind that trigonometry was, before the sixteenth century, generally considered merely as a part of astronomy. This is seen in the Greek work of Aristarchus (*ca.* 260 B.C.), Hipparchus (*ca.* 140 B.C.), Heron of Alexandria (*ca.* 50, or perhaps as late as 200), Menelaus (*ca.* 100), Ptolemy (*ca.* 150), the anonymous writer of the *Sūrya Siddhānta* (*ca.* 400), Āryabhāṭa (*ca.* 510), and most of the Arab and Persian writers. In the thirteenth century, however, Naṣîr ed-dîn al Ṭûsî, a Persian astronomer, wrote a work (*Shakl al-qaṭṭâ* ["Theory of transversals"]) in which it was considered as a separate subject. About the year 1464 Regiomontanus (1436–76) made a similar beginning in Europe, in his *De triangulis omnimodis libri V*, although the book was not printed until many years later (Nuremberg, 1533). It was not this work that influenced the sixteenth century to look upon trigonometry as a separate discipline; it was rather the same writer's *Tabula directionum* (*s.a.*, but printed before 1485, with three editions before 1501). The effect upon the sixteenth century is seen in such works as those of Copernicus and Rhaeticus.

Of all the instruments of mathematics, those which had the most extensive literature in the fifteenth and sixteenth centuries were the astrolabe (the "star-taker") and the armillary sphere.[47] Their use in astrology accounts for this prominence. For our purposes it will suffice to refer only to the astrolabe. The Greeks made much use of it in astronomy; the Arabs obtained their knowledge of it in the ninth century, from the Greeks and probably from the Hindus; the Jewish writers seem to have obtained theirs from the Arabs, and Messahala (*ca.* 800) wrote upon it:

Rabbi ben Ezra (*ca.* 1140) obtained the knowledge set forth in his treatise from the latter; and Chaucer in turn obtained (*ca.* 1380) his from these two Hebrew sources. Thus the instrument had been the subject of extensive study for nearly two thousand years before the writers of the fifteenth century made it still more widely known through the aid of the printed book. The medieval writers upon the subject included scholars like Hermannus Contractus (1013–54)[48] and Rabbi ben Ezra (*ca.* 1093–1167), both of whom were influenced by the extensive Arabic and early Jewish literature,[49] and who, in turn, influenced writers like Andalò de Negro (Andalius de Nigro, *ca.* 1260–*ca.* 1340), whose *Opus praeclarissimum astrolabii* was printed at Ferrara in 1475; Pietro d'Abano (*ca.* 1250–*ca.* 1316), whose work appeared later (Venice, 1502); and Chaucer (d. 1400), whose work on the subject was, as already stated, based largely on the treatises of Messahala and Rabbi ben Ezra.

7. *Calendar Reform*

It was not merely the *computus*, occupied as it was with the problem of fixing in advance the movable feasts of the church, that interested the mathematician and astronomer in the fifteenth century. The leaders, encouraged by the church, were also deeply concerned with the reform of the calendar as a whole. Nor was the problem by any means a new one. The Council of Nice (325) had been concerned with it in the fourth century, and had made a change in the Julian calendar which Caesar had decreed about 46 B.C. In 1337 a reconsideration of the problem had been urged by scholars like Jean de Meurs, and Pope Clement VI had raised the question a few years later.

The fifteenth century inherited this reform movement, and Regiomontanus was called to Rome to advise upon some plan for adjusting the feasts to their proper seasons. The various plans suggested in the fourteenth century had been passed on to the fifteenth, and those of the fifteenth were doubtless looked

upon as one of the greatest mathematical (astronomical) problems passed on to the sixteenth. It was not until 1582 that, owing largely to the skill of mathematicians like Aloysius Lilius (1510–76) and Christopher Clavius (1537–1612), our present calendar was sanctioned by the Church of Rome.

8. *Algebra*

The fifteenth century had inherited from the twelfth, thirteenth, and fourteenth centuries some knowledge of algebra, chiefly relating to equations. There were, for example, such translations from the Arabic as that of Robert of Chester's version (1145) of Mohammed ibn Mûsâ al-Khowârizmî's algebra,[50] and such Latin treatises as Fibonacci's *Liber quadratorum* (*ca.* 1225) and *Flos*,[51] and the *De numeris datis* of Jordanus Nemorarius (*ca.* 1225). In the same way, the contributions of the fifteenth century to the sixteenth were made more frequently through manuscripts than through printed books. These show a knowledge of two features—work with surds and the solution of linear and quadratic equations. An interest in these subjects is shown in such manuscripts as the Rollandus treatise, written in Paris in 1424, and now in the library of Mr. George A. Plimpton, and the Chuquet work, *Triparty en la science des nombres*, written in Lyons in 1484 and now in the Bibliothèque St. Geneviève, Paris.

Further evidence of this interest is found in the *Sūma* of Pacioli, mentioned above. In this there is an extended treatment of irrationals as represented by lines after the manner of the Greeks; of proportions of various kinds as set forth in Euclid, Book V; of different types of series, also of Greek origin; of the "Rule of false" (or "false position"),[52] an ancient method of solving problems, which was later replaced by the simpler method of equations; of "la Pratica de algebra & almucabala," with its explanation of the terms *cosa* (for x), *censo* (for x^2), *cubo* (for x^3), and the rules of signs ("*meno. via. meno. sempre. fa. piu.*,"

etc., fol. 112v); of binomial surds; and of equations (fol. 148r) with conventional problems such as persisted throughout the sixteenth century, and are to be found even in textbooks of the present day. The problems also relate to commercial affairs and often to real conditions in the fifteenth century, and some of them persisted long after these conditions ceased. In the manuscripts there was also some approach to a workable algebraic symbolism. Indeed, in the thirteenth century there are cases in which a letter was used to represent a number.[53] In general, however, the fifteenth century used initials, the Latin works having *R* for *res* (the unknown quantity), *ce.* for *census* (the square of the unknown), *cu.* for *cubus* (our x^3), and ℞ (*radix*, root) for our radical sign. For the unknown quantity there was also used a very common ligature for the Greek γ and ρ, the origin of which, in this sense, is itself unknown. It may have stood for γράμμα (a letter) or for γραμμή (a line), or it may have been a contraction of *radix*. From the use of *res*, "thing," by the late Latin writers, to represent the unknown quantity, the Italian algebraists used its equivalent in their language, *cosa*.[54] Hence they often called algebra the *Regola de la cosa*. In the sixteenth century this gave rise to the German *Coss*, as in Rudolff's algebra (*Die Coss*), which appeared in 1525,[55] and the English term "cossike art." Thus Andreas Helmreich, in his *Rechennbüch* of 1561, speaks of the Italians as calling it "das buch *Delacosa* welchs wir Deutschē de Regulā Cos oder *Algebra* nennen."[56] In any case, such are the words and symbols which, with natural modifications, characterized much of the algebra of the sixteenth century.

But the Italians and Germans in the fifteenth century also used the old Arabic title (*al-jabr w'al-muqâbalah*) for the science, with many variations such as *largibra*, *Reghola della raibre mochabiln°*, *ghabile*, *locibra umachabille*, from which the sixteenth century derived such titles as *Gebra vnd Almuthabola*.

Most of our present symbols used in elementary mathematics

are the product of the sixteenth and seventeenth centuries. The fifteenth century contributed two notable ones, however—the plus and minus signs, these appearing in print in the *Behēde vnd hubsche Rechnung* of Johann Widman (Leipzig, 1489). Although he lectured on algebra, he did not publish any book on the subject, and the symbols seem to have found no place in a printed work on algebra, in which subject they chiefly belong, until Vander Hoecke,[57] in 1514, used them in his treatment of polynomials.

Of the genius shown by Oresme[58] in suggesting in his *Algorismus proportionum*[59] the use of fractional exponents, little need be said in this paper, since the invention had no noticeable effect upon either of the centuries here considered.

Negative numbers were recognized in the abstract, as a special type of number, by the Hindus, appearing in the works of Brahmagupta (*ca.* 628) and other later writers. The Arabs of the ninth century knew the usual rules relating to them. In the fifteenth century they were recognized as roots of an equation, as by Chuquet (MS, 1484), and thus developed they became an inheritance of the sixteenth century. Here they found fairly adequate treatment by such writers as Cardan (*Ars magna*, 1545), whose great prestige gave them a distinct standing in algebra. It was not, however, until such seventeenth-century writers as Harriot, Fermat, Descartes, Hudde, and Wallis, partly by analysis and partly by graphic treatment, showed their real significance that they found a place in what we look upon as elementary algebra. The meaning of a surd number like $\sqrt{2}$, and the methods of finding its approximate value, were two problems going back to the days of the Pythagoreans two thousand years before the fifteenth century closed. The Arab scholars inherited the methods of the Greeks; the late Middle Ages of Europe inherited those of the Arabs; the fifteenth century inherited theirs in turn, and in the *Triparty* of Chuquet (MS, 1484) an improvement in the methods of approximation ap-

pears, possibly suggested by some now forgotten writer. It was in turn passed along to such sixteenth-century writers as Ortega (1512) and De la Roche (1520), the latter having freely plagiarized from the unpublished manuscript of Chuquet.

The plan of the fifteenth century of placing a treatment of surds before the study of irrational equations, as shown in the Rollandus MS of about 1424 and in Pacioli's *Sūma* of 1494, was adopted by the algebraists of the sixteenth century although the real significance of irrational numbers in general was not perceived until three centuries later.

The fifteenth century seems to have begun to awaken to the vague idea that an expression like $\sqrt{-2}$ might possibly have a meaning. At any rate, Chuquet (1484) seems to have thought that it represented an impossible root, while Pacioli (1494) stated that certain specified equations could not be solved because the roots were of this form. The situation was left to be cleared up in part by Cardan in his *Ars magna* (Nuremberg, 1545), who was the first to use such numbers in computation. The rest of the solution of the problem, to represent graphically the meaning of such numbers and to make them real, as had already been done with fractions and surds, was not achieved until the close of the eighteenth century.

The Greeks knew how to solve the equivalent of a quadratic equation by the aid of geometry. They could even solve certain cubic equations by the same means. The Hindus and the Arabs were very ingenious in their rules for the quadratic, and the Arabs could solve a certain type of cubic. Even long before the Greeks, the evidence seems to show that the Babylonians (using the term in a general way) could find one root of a quadratic equation of three terms.

The fifteenth century saw this work systematized and knew of the leading attempts already made to solve the cubic. It had no worthy symbolism, the equation $x+x^2=12$ appearing in Pacioli's *Sūma* (1494) as "Trouame .1.n° che giōto al suo q̄drat°

facia .12." In spite of the lack of favorable symbols, however, equations had been classified as to types for the first four degrees by the poet-algebraist Omar Khayyám about A.D. 1100. This was the status of the work when Pacioli wrote, and the challenge which was passed on to the sixteenth century was to create a better symbolism and to solve the cubic and quartic equations. This challenge, to use a conventional figure of speech, was accepted and the results as to the equations and somewhat as to the symbols appeared in Cardan's *Ars magna* (1545). The symbols were more definitely improved by Viète (Vieta) in the last decade of the century, at first printed privately and later made known more widely by Frans van Schooten in the *Opera mathematica* of Vieta (Leyden, 1646), and by other writers of the seventeenth century. Even more successfully, Harriot, after his return from surveying part of the southern colonies of North America, greatly improved the symbolism, but this was after the close of the sixteenth century, and just before our present algebraic symbols had been suggested and used by Descartes.

9. *Geometry*

Aside from a mere mention of the common geometric figures, this subject was practically unknown in the Dark Ages. Boethius (d. 524) wrote a paraphrase of Euclid, although it is certain that the text of this version which has come down to us has been greatly altered since his time. The text of Euclid, based upon a translation from the Arabic, appeared in the fifteenth century (Venice, 1482) and assisted in arousing the interest in Greek geometry that is so apparent after the year 1500. Gerbert (Pope Sylvester II, d. 1003) also wrote upon geometry, but apparently without Euclid's *Elements* to inspire him. Greek manuscripts of Euclid, while not common, existed in the Middle Ages, for one written by Theon of Alexandria, father of Hypatia, was still in use in the sixteenth century and later.[60a]

The Arab translations of Euclid from the Greek date from the

eighth century, and the Latin versions from the Arabic begin in the twelfth century. From a list of textbooks used in the University of Paris about 1175 it appears that the works of Boethius, Euclid, and Ptolemy were at least known,[61] and similar evidence appears in the Sicilian version (*ca.* 1160) of Ptolemy's *Almagest.*[62] Indeed, the twelfth century was a period of the awakening of Europe to the works of the Greek scientists in general. In the Sicilian version (*ca.* 1160) of Ptolemy's *Almagest*, for example, mention is made of the work of "Claudius Ptolomeus . . . . qui a Grecis quidem mathematica seu megisti sintaxis, a Sarracenis vero almegesti corrupto nomine appellantur."[63] It also mentions Euclid, Proclus, Boethius, and Aristotle, and various medieval writers. From that time on, manuscripts of the Greek writers were available for study, and beginning with the fourteenth century some knowledge of Euclid was required in several universities.

The great contribution of the fifteenth century in the field of elementary geometry was the printing of Euclid's *Elements* by Ratdolt,[64] using the Latin translation by Campanus (*ca.* 1260) from the Arabic, and "the first printed mathematical book of any importance."[65] Its influence was immediately felt, since several other editions appeared before 1501. The effect upon the sixteenth century was naturally more far-reaching. The first complete Latin translation from the Greek was that of Bartolomeo Zamberti (Venice, 1505), and the most scholarly of the early Latin editions was that of Federigo Commandino (1572), which became the basis of all editions of importance before the nineteenth century.

In Great Britain, Euclid seems to have been known as early as the tenth century, if we may trust to a poem written four hundred years later, and which asserts:

> The clerk Euclyde on thys wyse hyt fonde,
> Thys crafte of gemetry yn Egypte londe; . . . .
> Thys craft com ynto Englond as y thow say
> Yn tyme of good kynge Adelstonus day.[66]

Influenced by the Continental interest in Euclid's great classic, England began to give it attention in the second half of the sixteenth century. Robert Recorde, in a summary in *The pathewaie to knowledge* (London, 1551), and John Dee and Henry Billingsley in a translation of the *Elements* (London, 1570),[67] did the most to make the work known in Great Britain.

Riccardi, in his *Saggio di una bibliografia Euclidea* (Bologna, 1887, 1893), lists one hundred and thirty-five editions of the work in the sixteenth century, and more than a thousand altogether. He further asserts that no book except the Bible ever went through so many distinct editions—a statement that may be challenged, but which admits of no doubt if we include all geometries which are simply Euclid revised for school purposes.

Geometry in the fourteenth and fifteenth centuries was little more than Euclid as diluted by Boethius, and often little more than definitions. There were, however, exceptions, but these had little effect upon later writers. Among the exceptions may be mentioned the work of Nicole Oresme (*ca.* 1323–82), who wrote *Tractatus de latitudinibus formarum* and *Tractatus de uniformitate et difformitate intensionum.* In these he took the first step of much value toward the co-ordinate system which is the basis of analytic geometry. Even in the fourteenth century the importance of his work was recognized, as witness the fact that the university of Cologne as early as 1398 decreed that "Bacalarius temptandus debet audivisse . . . . tractatum de latitudinibus formarum." Toward the close of the fifteenth century this treatise was twice printed,[68] and other editions followed a few years later.[69]

The real use of the device in geometry was not fully recognized, however, until the seventeenth century.

Related to geometry was the science of optics, which included, even in classical times, the subject of perspective. It attracted the attention of the Arabs, the work of Alhazen[70] becoming the basis of that of the British scholar, John Peckham,[71] archbishop

of Canterbury, whose *Perspectiva communis* (*ca.* 1280) was a standard treatise until well into the seventeenth century. It was printed in Milan in 1482, edited by Facio Cardano (1444–1524), the father of the great mathematician, and was printed several times in the sixteenth century. The subject was also considered by such other medieval writers as Roger Bacon (1214–94) and Robert Grosseteste (*fl.* 1240), the latter writing a work upon it. Much more attention was naturally given to it by the painters and architects of the Renaissance period, such as Pietro Franceschi (d. 1492),[72] Leonardo da Vinci (*ca.* 1500), Benvenuto Cellini (1500–*ca.* 1571), and Albrecht Dürer (1471–1528),[73] not to speak of other such sixteenth-century writers as Georg Tanstetter von Thannau (1480–1530), Apianus (Peter Bienewitz, 1495–1552), and the celebrated philosopher Petrus Ramus (Pierre de la Ramée, 1515–72), who also edited Euclid and wrote on the theory of numbers.

With respect to the applications of geometry it is interesting to observe that Robertus Valturius of Rimini published at Verona in 1472 a work entitled *De re militari libri XII*,[74] in which, in the second book, he treated "de arithmetica & militari geometria," a forerunner of numerous works on military mathematics appearing particularly in England and France in the sixteenth century and later.

Notes

1. Pietro Riccardi, *Biblioteca matematica italiana* (2 vols.; Modena, 1880, 1893), II, xi.

2. *Arithmetica boetij* (Augsburg, 1488). Other editions appeared in the fifteenth century, and several in the century following.

3. Six or seven Italian editions appeared in the fifteenth century, and three outside of Italy. See the *Gesamt-Katalog* and also Boncompagni's *Bullettino*, IV, 498.

4. The first edition of his arithmetic, *Nicomachi Gerasini arithmeticae libri duo* (Paris, 1538), did not appear in print until fifty years after that of Boethius and was never as well received.

5. There was another edition (Modena, 1500), and several in the sixteenth century. The seventh *liber* is "De arithmetica," and contains some religious mysticism of numbers, which probably accounts for the frequency of the later editions.

6. His *De artibus ac disciplinis liberalium literarum*, containing the *Compendium*, was published at Basel in 1528. The *Compendium* was printed separately in Paris in 1540.

7. There were six or more editions in the fifteenth century.

8. His *Arithmetica*, already mentioned, was printed at Paris in 1495, and frequently thereafter.

9. His arithmetic was printed in Paris in 1496.

10. His *Arithmetica cōmunis* was printed in Vienna in 1515.

11. I.e., Mohammed the son of Moses, from Khwarezm, a region about Khiva. He also wrote the first book called algebra, *ʿIlm al-jabr wa'l muqabalah*.

12. I.e., Al-Khowârizmî, using the genitive of *Algoritmus*.

13. It was printed in his *Opera* (Venice, 1494), and earlier in Strasburg. See Copinger, Part II, Nos. 6242 f.

14. First printed at Strasburg in 1488. In the same year Strasburg printed another medieval classic, the *Compotus manualis* of Anianus, mentioned later.

15. Not printed among the incunabula, but apparently widely circulated in manuscript form. It was printed in J. O. Halliwell's *Rara mathematica* (London, 1838).

16. But as to doubts see G. Eneström, *Bibliotheca mathematica*, V (3), 9.

17. First printed at Padua in 1483. From a note in the Venice edition of 1540 it appears that it was written in 1410.

18. There was an *Algorithmus*, without date or author, printed at Venice *ca.* 1476–78. The first dated arithmetic appeared at Treviso in 1478, also anonymous.

19. At Trent, *ca.* 1475.

20. In Latin books the counters were often called *projectiles*, whence the French *getons*, from *jacere*, "to throw"—pieces thrown or cast on the table, thus giving rise to "casting an account," and to "counter" as a board in a shop or bank.

21. The first notable case is that of the *Liber abaci* of Leonardo Fibonacci, written in 1202.

22. There is also a [*T*]*abula abaci quę pytagorea m̄sa uocatur* of the twelfth century in the Vatican. In the Bibliothèque Nationale (Paris) there is some correspondence early in the eleventh century in which the writer says, "Hoc si abacizando probaveris," and in the same MS there is a letter to Hermannus Contractus with the statement: "Ut meam abicizandi notem inscitiam." See D. E. Smith, *History of mathematics* (Boston, 1923, 1925), II, 177.

23. C. H. Haskins, *Studies in the history of mediæval science* (Cambridge, Mass., 1924), chap. xv; R. L. Poole, *The exchequer in the twelfth century* (Oxford, 1912).

24. *Le livre des getz*, *s.l.a.*, *ca.* 1500; J. Clichtoveus, *Ars supputādi tam per calculos qz notas arithmeticas* (Paris, 1507).

25. *Ain New geordnet Rechenbiechlin auf den linien mit Rechenpfeningen* (Augsburg, 1514). Köbel was a fellow-student with Copernicus at Cracow. There were three kinds of arithmetics bearing his name.

26. He published four arithmetics, three of which made much of counter reckoning. "Nach Adam Riese" is an expression still used in Germany.

27. It closes: "Finito ellibro de tvcti ichostvmi: cambi: monete: pesi: misvre: & vsanze di lectere di cambi: & termini di decte lectere che nepaesi si costvma et in diverse terre."

28. In the first edition the name appears Piero Borgi, but in later ones the spelling Borghi is commonly used.

29. First edition, Venice, 1484. There were four editions in the fifteenth century and thirteen in the sixteenth. In some editions there is a title, such as *Libro de abacho.*

30. Luca de pacioli dal borgo sā sepulchro, as the name appears in his *supplica* to the Doge of Venice, December 29, 1508 (b. *ca.* 1444; d. probably after 1509).

31. His *Opus aureum calculationum* was published at Padua in [1485]. There were later editions. The name has numerous variants such as Swiseth, Suicetus, Swinshead, and Swincetus.

32. The matter is summarized in the author's *Rara arithmetica* (Boston, 1908) and his *History of mathematics* (2 vols.; Boston, 1932, 1925).

33. C. I. Gerhardt, *Études historiques sur l'arithmétique de position* (Berlin, 1816), Prog., p. 4.

34. Haskins, *op. cit.*, p. 86.

35. These figures are taken from the writer's *Le comput manuel de Magister Anianus* (Paris, 1928). Since its publication two other editions have been reported.

36. Venice, 1501. This edition bears the words "Nouiter Impressum," although I have found none earlier. There were others in the sixteenth century.

37. Consider such works as those of Raymundus Massilensis, in 1140 (see Haskins, *op. cit.*, p. 96).

38. On these translations see *ibid.*, pp. 104, 157. In this connection the work of Theodosius (*ca.* 100) on the sphere, so much in favor in the sixteenth century, should be recalled. It was first printed in complete form in 1529, but in part at Venice in 1518.

39. E. Narducci, in Boncompagni, *op. cit.*, XVII, 1, 43, 165. Bartolomeo was considerably indebted to the so-called Pseudo-Boethius.

40. See Haskins, *op. cit.*, chap. xiii.

41. L. Thorndike, *Science and thought in the fifteenth century* (New York, 1929), p. 141, with Bibliography.

42. Abraham Judaeus, known by the Arabic name of Sahib al-Shorta, "Chief of the Guards," whence Plato of Tivoli's (*ca.* 1120) use of the name Savasorda.

43. It was printed in Venice in 1528. The *editio princeps* of the Greek text was first published at Basel in 1538.

44. *Epytoma Ioānis De mōteregio in almagestū ptolomei* (Venice, 1496). Peurbach (1423–61) is said to have begun it.

45. Latin version of Peter Liechtenstein (Venice, 1515).

46. Peurbach, *Theoricae novae planetarvm* (Venice, 1495), with two other editions before 1501; *Tractatus . . . . super propositiones Ptolemai de sinubus et arcubus* (Nuremberg, 1541).

47. Astrolabe, from ἄστρον (*astron*, a heavenly body, a star)+λαμβάνειν, λαβεῖν (*lambanein*, *labein*, "take"). Armillary, from *armilla*, a hoop or ring, referring to the shape of the instrument with its three rings.

48. There is a beautiful twelfth century manuscript of his work in the British Museum.

49. E.g., 'Alî ibn 'Isâ al-Aṣṭorlâbî (*ca.* 830) and Mâ-shâ'-allâh ibn Aṯarî (Messahala, the Jewish writer mentioned above).

50. Translated into English by L. C. Karpinski (New York, 1915). See also C. H. Haskins, "Robert of Chester," *op. cit.*, p. 120.

51. For a bibliography of Fibonacci (*ca.* 1170–*ca.* 1250) see G. Loria, *Gli scienziati italiani* (Rome, 1919); B. Boncompagni, *Scritti di Leonardo Pisano* (2 vols.; Rome, 1857, 1862).

52. "De regulis helcataym que vulgo due false positiones nuncupantur" (fol. 98v); "Casus exemplares simplicis positionis" (fol. 99r); "De regulis duple positionis" (fol. 100r).

53. E.g., in *De numerus datis*, by Jordanus Nemorarius (*ca.* 1225).

54. From Lat. *causa;* cf. Fr. *chose.*

55. It was later (1553–54) edited by Michael Stifel.

56. 1588 ed., fol. b2.

57. In the 1537 edition the name is printed Gielis vandē hoecke. The title as there given is *Een sonderlinghe boeck in dye edel conste Arithmetica.*

58. Nicole Oresme (Oresmus, Horem, Horin, *ca.* 1322–82), a man of more genius in mathematics than any of his contemporaries.

59. It was printed in Venice in 1505, in connection with works by Bradwardin and Suiceth (Suiseth).

60. Peyrard, who edited Euclid from the Greek in 1804, found an earlier copy; at least it was earlier in the original form in which the translation was made.

61. Haskins, *op. cit.*, pp. 369, 374. The list gives "Institutis arsmetice informandus Boecii et Euclidis legat," relating to the parts of Euclid's *Elements* on number theory. "Deinde ad theoremata geometrie que ordine artificiosissimo disponit Euclides in suo libro," relating to his geometry.

62. *Op. cit.*, p. 191.

63. Haskins, *op. cit.*, p. 191.

64. *Preclarissimus liber elementorum Euclidis* (Venice, 1482).

65. Sir Thomas Heath, *A history of Greek mathematics* (Oxford, 1921), I, 364; *The thirteen books of Euclid's "Elements"* (2d ed.; Cambridge, 1926, I, 97).

66. MS Bib. Reg. 17A, I, 32, published by J. O. Halliwell, *The early history of freemasonry in England* (London, 1840).

67. John Dee wrote the Preface and may have done part of the translating.

68. Padua, 1482 and 1486.

69. Venice, 1505; Vienna, 1515.

70. Al-Ḥasan . . . . ibn al-Ḥaiṯan (*ca.* 965–1039).

71. B. before 1240; d. 1292.

72. His *De perspectiva pigendi* was then known only in manuscript and through his pupils.

73. *Underweysung der messung* (Nuremberg, 1525). It contains some treatment of perspective.

74. There were two other editions in 1493, and another, with the title changed, the same year.

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